25 (3), 2024, 1549-1558

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

The Impact of the Group Investigation (GI) Learning Model on Enhancing Middle School Students' Science Literacy in Thermal Expansion Topics

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Abstract: Scientific literacy is essential skills that students must master in the 21st century. This study aims to examine the effect of the Group Investigation (GI) learning model on improving science literacy in Middle School students on thermal expansion. The research uses a pre-experimental method with a one-group pretest-posttest design. The sample consisted of one class selected through purposive sampling, namely class VII I at SMP Negeri 5 Yogyakarta. The data collection method involved using a test with a science literacy test in the form of multiple-choice questions. Data analysis was conducted using statistical tests to determine the differences before and after implementing the GI learning model. The study results indicate that the Group Investigation (GI) learning model can improve students' science literacy on thermal expansion. The enhancement in science literacy scores for indicators such as explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically showed increases of 35.1%, 40.02%, 22.08%, and 39.98%, respectively. The paired sample T-test results indicated that the GI learning model significantly affected science literacy and its indicators. The N-gain test results showed that the GI learning model positively affected science literacy, with the indicators achieving scores of 0.42, 0.64, 0.39, and 0.29, categorized as moderate, moderate, moderate, and low, respectively. The calculated Cohen's d value of 1.457024 falls within the huge category based on Sawilowsky's (2009) criteria. This study concludes that implementing the GI learning model can improve students' science literacy on thermal expansion.

Keywords: group investigation, science literacy, thermal expansion, middle school.

▪ INTRODUCTION

In today's era of globalization, science literacy is an essential skill that students must master. Science literacy and 21st-century skills are two abilities that can equip students to tackle the challenges of the modern world. Teachers must integrate these skills in the science classroom (Hanson, 2022). Science literacy includes understanding scientific concepts, applying scientific knowledge in daily life, thinking critically, and making decisions based on valid information. Science literacy addresses everyday science-related problems (Kelp et al., 2023). Carneiro and Draxler (2008) explain that successful education is built on four pillars: learning to know, learning to do, learning to be, and learning to live together. This philosophical and pragmatic framework emphasizes the importance of the educational community's role and the balance between knowledge and action, as well as individual and social learning.

In Indonesia, students' science literacy has not progressed significantly since participating in PISA from 2000 to 2022. In 2022, Indonesia ranked 67th out of 80 countries, with an average science score of 485 for OECD countries, while Indonesia's score was only 383 (OECD, 2022). Research and classroom observations reveal that many students still have limited science literacy. They struggle to understand scientific concepts deeply and often face difficulties communicating their understanding of science. One of the factors contributing to low science literacy is the predominant use of direct

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DOI: http://dx.doi.org/10.23960/jpmipa/v25i3.pp1549-1558
Received: 13 December 2024
Accepted: 31 December 2024
Published: 01 January 2025

instruction methods. Teaching centered solely on the teacher does not encourage students to actively think critically, engage in discussions, or develop analytical skills. Students' abilities remain low due to the lack of variation in teaching models (Haryono, 2020). Subudi (2021) found that several factors, such as 1 caused students' inadequate abilities) students' perception that teachers are the primary source of information in learning, 2) students not being accustomed to identifying concepts, and 3) students rarely engaging in pre-class material literacy at home. Fuadi et al. (2020) explain that the causes of low scientific literacy include non-contextual learning that is not related to everyday life, an unfavorable learning environment, and the selection of textbooks that are not engaging and applicable.

Various strategies and teaching models can be used to enhance science literacy and promote 21st-century skills. Improving science literacy in the classroom can be achieved through vocabulary instruction to increase content knowledge, scientific reading, comprehension skills, writing, data analysis, and interpretation, engaging students in argumentation, and teaching through socio-scientific issues (Hanson, 2022). Sharma et al. (2024) found that the GI learning model effectively improves student learning outcomes. Research by Subudi (2021) and Bertucci et al. (2010) shows that the GI cooperative learning model directly trains students' science skills through the application of group investigation activities. Through investigation and group discussions, students are encouraged to develop analysis, synthesis, and evaluation skills concerning problems. Additionally, this learning model encourages students to be more open and confident in expressing opinions and Enhances their ability to speak and discuss scientifically.

Conventional teaching methods should shift toward student-centered learning, such as small group learning, where students collaborate as a team to solve problems, complete tasks, and achieve common goals, often known as cooperative learning (Artz & Newman, 1990). The Group Investigation (GI) model is a cooperative learning model that can Enhance science literacy and students' communication skills. The GI model provides opportunities for students to collaborate in small groups and actively discuss and plan learning activities through group investigations (Sharan & Sharan, 1992). They are encouraged to work in teams, define problems, conduct research, discuss findings, and present their results in class. This learning model emphasizes cognitive aspects and develops affective and social aspects. According to Kagan & Kagan (2009), the steps in the GI learning model are: 1) selecting a topic, 2) cooperative planning, 3) implementation, 4) analysis and synthesis, 5) presenting final results, and 6) group evaluation. The stages of cooperative planning, implementation, analysis, and synthesis are indicated and expected to enhance students' scientific literacy skills.

Based on this background, this study examines how much the Group Investigation learning model influences enhancing students' science literacy. By applying this model, students are expected to gain a deeper understanding of science and develop strong communication skills in conveying ideas and scientific information.

▪ METHOD

Participants

The research population subjects in this study were 10 classes at SMP Negeri 5 Yogyakarta. The sample in this study was Class VII I, consisting of 26 students selected through purposive sampling. Class VII I was specifically chosen because it represented a

heterogeneous group regarding academic ability, gender, and socioeconomic background and exhibited a normal distribution in student performance. Additionally, the students in this class had relatively low initial science literacy levels, making them an ideal sample to evaluate the effectiveness of the GI learning model in addressing and improving science literacy comprehensively.

Research Design and Procedures

This study uses a pre-experimental method with a One-Group Pretest-Posttest Design (Creswell, 2014). In this design, one class will be the research subject and receive instruction using the GI learning model. Students will be given a pretest and posttest to measure the enhancement in their science literacy. The research utilized a One-Group Pretest-Posttest design, as described below. Students' science literacy levels were measured before implementing the Group Investigation (GI) learning model; the GI learning model was applied to enhance students' science literacy. Students' science literacy levels were re-assessed after applying the GI learning model.

The study was conducted in November 2024 during the 2024/2025 academic year, focusing on thermal expansion. Implementing the GI model on thermal expansion was done through various practical activities to provide students with hands-on learning experiences. The thermal expansion of solids was observed using Muschenbrock equipment and bimetal, allowing students to understand changes in the dimensions of solid objects due to temperature increases. The expansion of liquids was demonstrated using alcohol in a thermometer, showing changes in liquid volume as the temperature rose. Meanwhile, the expansion of gases was observed by using gas in a balloon connected to an Erlenmeyer flask, enabling students to see changes in gas volume directly.

Instruments

The research instrument consisted of a science literacy test with multiple-choice questions. These questions were designed to measure students' science literacy, covering indicators such as explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically (OECD, 2023). The science literacy test consists of 13 questions designed to measure students' science literacy skills. Items 1, 2, 3, 4, and 6 are used to scientifically measure the indicator of explaining phenomena. Items 9, 12, and 13 are used to measure the indicator of evaluating and designing scientific investigations. Items 5, 7, 8, 10, and 11 are used to measure the indicator of interpreting data and evidence scientifically. The validity and reliability of this science literacy test have been tested through expert judgment to ensure that the instrument used is appropriate and reliable in measuring students' science literacy skills.

Data Analysis

The data collected were then analyzed to determine the effect of the GI learning model through descriptive statistical analysis, paired sample t-tests, and N-gain using SPSS 25 software based on pretest and posttest results. The data collected were then analyzed to determine the effect of the GI learning model by employing descriptive statistical analysis using SPSS 25 software. Descriptive statistical analysis is crucial in summarizing and interpreting the pretest and posttest results. This method provides essential insights into mean, standard deviation, and variance, which help understand the

data's central tendency and dispersion.

To analyze the effectiveness of the learning model implementation in improving students' science literacy, normalized gain (n-gain) calculations were performed. The n-gain value measures the extent of enhancement in the average science literacy score, including each indicator, before and after the learning intervention. Students' average science literacy scores in the pretest and posttest stages are compared to determine the degree of enhancement, which is then categorized into low, medium, or high levels according to predefined criteria (Hake, 2002). Hake (2002) explains that N-Gain can be calculated using the following equation: The N-Gain categories are presented in Table 1.

$$N - Gain = \frac{Posttest\ score\ -\ Pretest\ score}{Maximum\ score\ -\ Pretest\ score}.$$

Table 1. N-Gain categories by hake (2002)

Category	N-Gain Value
Low	N-Gain < 0.30
Medium	0.30 ≤ N-Gain ≤ 0.70
High	N-Gain > 0.70

The effect size test determines how much the GI model influences science literacy. Cohen's d test is used to calculate the effect size, and the equation is as follows: The Cohen's d categories are presented in Table 2.

$$Cohen's\ d\ = \frac{(M2\ -\ M1)}{SD_{pooled}}$$

Table 2. The cohen's d categories by sawilowsky (2009)

Category	N-Gain Value
Very small	0.01
Small	0.20
Medium	0.50
Large	0.80
Very large	1.20
Huge	2.0

▪ RESULT AND DISSCUSSION

This study examines the effect of the Group Investigation (GI) learning model on improving science literacy in Middle School students on thermal expansion. The data obtained after implementing the GI learning model were tabulated and analyzed using descriptive statistics. The analyzed data shows students' science literacy levels before and after applying the GI learning model, as presented in Figure 1.

Figure 1 provides information on students' average science literacy scores and each indicator before and after implementing the GI learning model. After implementing the GI model, the average science literacy score increased by 35.1%, from 54.73 to 73.96. The indicator of explaining phenomena scientifically increased by 40.02%, from 61.54 to 86.15. The indicator of evaluating and designing scientific investigations increased by 22.08%, from 64.10 to 78.21. The indicator of interpreting data and evidence

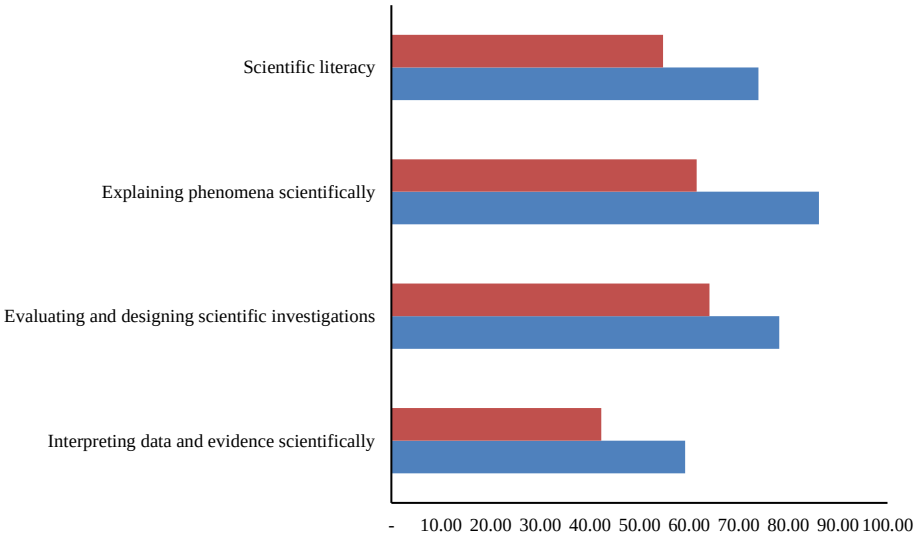

Figure 1. Science literacy and science literacy indicators before and after the gi learning model implementation

scientifically increased by 39.98%, from 42.31 to 59.23. These descriptive statistical analyses and descriptions show a significant enhancement in students' science literacy after implementing the GI learning model.

The average science literacy score and each science literacy indicator were then tested through statistical analysis using a paired sample T-test with SPSS 25 software at a 5% significance level to determine whether there was a significant enhancement in science literacy after implementing the GI learning model.

Science Literacy

The results of the Paired Sample T-Test for science literacy scores show that the mean score for the pretest was 54.73, with a standard deviation of 13.816, based on a sample size of 26 students. The mean score for the posttest increased to 73.94, with a standard deviation 12.521. The significance value (p-value) is 0.000. The Paired Sample T-test analysis results show a significant increase in students' science literacy scores after applying the Group Investigation (GI) model. The statistical test showed a significance value (Sig. 2-tailed) of 0.000 ($p < 0.05$), meaning there was a significant difference between the pretest and posttest scores.

Based on the research findings, the Group Investigation (GI) learning model has been proven to positively impact students' science literacy, as reflected in the pretest and posttest scores, which were analyzed using descriptive statistics and Paired Sample t-tests. Kelp et al. (2023) explain that in the GI learning model, students actively engage in the learning process through group work, discussions, and collaborative investigations. This active involvement encourages students to understand science concepts better, develop science literacy skills, and relate scientific knowledge to everyday situations. Science literacy refers to how one processes facts and scientific concepts and interprets scientific data with knowledge and scientific processes.

Indicator of Explaining Phenomena Scientifically

The results of the Paired Sample T-Test for the indicator of explaining phenomena scientifically reveal a significant improvement in students' performance. The mean score for the pretest was 61.54, with a standard deviation of 23.949, based on a sample of 26 students. After the intervention, the mean score increased to 86.15, with a standard deviation 16.752. The significance value (p-value) is 0.000. The Paired Sample T-test analysis shows a significant increase in the scores for the indicator of explaining phenomena scientifically after the GI model was applied. The significance test yielded a p-value of 0.000 (Sig. 2-tailed < 0.05), indicating that the difference between the pretest and posttest scores is statistically significant. Fauzi et al. (2021) explain that seeking information is directed toward various sources, such as student books, reference books, and websites available on the Internet that are relevant to the topic being studied. From this explanation, it is clear that the process students engage in fosters critical thinking and analytical skills, essential components of science literacy. Inquiry-based learning also allows students to ask questions, formulate hypotheses, and conduct small experiments that support a deeper understanding of scientific concepts. The GI learning model encourages students to develop good communication skills to understand literature, process information, communicate it in presentations, and interact within groups (Aini et al., 2018; Zayyin, 2017).

Indicator of Evaluating and Designing Scientific Investigations

The results of the Paired Sample T-Test for the indicator of scientific investigations show a notable improvement. The pretest mean score was 64.10, with a standard deviation of 23.949, based on a sample size of 26 students. After the intervention, the posttest mean score increased to 78.21, with a standard deviation 16.752. The significance value (p-value) of 0.046. Data analysis using the Paired Sample T-test shows a significant increase in scores for the indicator of evaluating and designing scientific investigations after the GI learning model was applied. The significance test yielded a Sig. (2-tailed) value of 0.046, indicating a significant difference between pretest and posttest scores at a 5% significance level ($p < 0.05$). Hanson (2022) states that science literacy involves knowing the science content, understanding the methods and procedures used by scientists, and applying this knowledge in everyday life as a citizen.

Indicator of Interpreting Data and Evidence Scientifically

The results of the Paired Sample T-Test for the indicator of interpreting data and evidence scientifically are as follows. The pretest mean score was 42.31, with a standard deviation of 13.056, based on a sample size of 26 students. After the intervention, the posttest mean score increased to 59.23, with a standard deviation 15.472. The significance value (p-value) is 0.000. The Paired Sample T-test analysis shows a significant increase in scores for the indicator of interpreting data and evidence scientifically after the GI model was implemented. The Sig. (2-tailed) value of 0.000 indicates that this increase is statistically significant at the 5% significance level ($p < 0.05$). Delismar et al. (2013) state that the GI learning model benefits students by helping them explore experiences and information during the learning process. This fact shows that the model can encourage enhancing students' science literacy. The stage of conducting investigations is crucial for enhancing science literacy. Fathurrohman (2017) explains that conducting investigations

includes essential stages, such as gathering information/literature, analyzing data, evaluating information, and drawing conclusions. Activities such as brainstorming, discussion, and student classification accompany these stages.

Results of the N-gain Calculation

Table 3. N-Gain calculation for science literacy and each indicator

Assessment Results	Pretest	Posttest	N-Gain	Category
Science Literacy	54.73	73.96	0.42	Medium
Indicator				
Explaining phenomena scientifically	61.54	86.15	0.64	Medium
Evaluating and designing scientific investigations	64.10	78.21	0.39	Medium
Interpreting data and evidence scientifically	42.31	59.23	0.29	Low

The N-gain analysis results show that implementing the Group Investigation (GI) learning model moderately improves students' science literacy overall. For the first indicator, explaining phenomena scientifically, there was a significant enhancement with a medium category. This indicates that the GI learning model is effective in helping students deeply understand and explain scientific concepts. Slavin (2015) and Fathurrohman (2017) explain that the GI learning model encourages students to conduct investigations, which motivates them to seek information from various sources and process that information through discussions to complete group tasks, analyze, and present information related to the topics being studied.

The collaborative investigation-based learning process allows students to explore scientific phenomena critically, thus enhancing their understanding. For the second indicator, evaluating and designing scientific investigations, the n-gain value falls into the medium category. Although the enhancement is not as high as in the first indicator, it shows that students could develop evaluative thinking skills and design experiments more systematically. Student interactions during the investigation process positively contributed to this achievement. Sharan and Sharan (1992) explained that the GI model allows students to collaborate in small groups, engage in active discussions, and plan learning activities through group investigations.

However, for the third indicator, interpreting data and evidence scientifically, the n-gain value is categorized as low. This result indicates that, despite some enhancement, students' ability to interpret data and evidence has not developed optimally. One possible reason for this could be the complexity of the material or time constraints in guiding students during the data analysis phase. Therefore, special attention is needed in the implementation of the GI learning model to place more emphasis on mastering data interpretation skills.

The GI learning model places students at the center of learning, motivating them to learn independently and collaboratively. In this model, students actively search for and process scientific literature, fostering a greater sense of responsibility for their learning. The teacher is a facilitator, guiding discussions and ensuring the learning process remains focused and effective. To address areas where students show lower outcomes, such as interpreting data and evidence scientifically, teachers can integrate practical tools and

strategies to support learning. For instance, incorporating simple software for data visualization, such as interactive graphing tools or spreadsheet applications, can help students better understand and interpret data. These tools allow students to experiment with different ways of organizing and visualizing information, making abstract concepts more tangible. Additionally, teachers can provide structured activities, such as group data analysis projects or step-by-step tutorials on interpreting scientific data, to reinforce these skills within the GI framework.

The findings of this study indicate that the Group Investigation (GI) learning model significantly enhances middle school students' science literacy, particularly on the topic of thermal expansion. The calculated Cohen's d value of 1.457024 falls within the huge category based on Sawilowsky's (2009) criteria, demonstrating the substantial impact of this learning model. The GI model's emphasis on collaboration, active discussion, and group investigations likely contributed to this improvement, as supported by Sharan and Sharan (1992), who highlighted that GI provides opportunities for students to plan and engage in meaningful learning activities. Additionally, previous research has shown that collaborative learning models foster a more profound understanding and engagement with scientific concepts (Gillies, 2016).

These findings support previous research that indicates the GI learning model can improve student engagement and concept understanding through group work and collaborative discussions (Santyasa, 2020). Other studies also show that the GI learning model can help students develop critical thinking skills and significantly improve problem-solving abilities (Johnson & Johnson, 2017). Thus, implementing the GI learning model can be a potential alternative to improving science literacy competencies in educational settings. Zorlu and Sezek (2020), Kartikawati et al. (2020), and Misa et al. (2023) explain that the Group Investigation model can enhance students' academic abilities and science process skills (SPS). Their research findings show that strong academic abilities and SPS significantly enhance science literacy.

▪ CONCLUSION

The Group Investigation (GI) learning model has demonstrated a significant positive impact on enhancing students' science literacy, making it a promising approach in education. Science literacy, which encompasses the abilities to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically, showed marked enhancement among students engaged in GI-based learning activities. The results of the N-gain test further underscore the effectiveness of the GI model in fostering these competencies. This finding highlights the importance of implementing collaborative and inquiry-based learning models, such as GI, to better prepare students for the demands of scientific understanding and problem-solving in real-world contexts.

The implications of this research for education are substantial, as it provides evidence supporting the integration of collaborative learning strategies to improve critical skills in science education. By fostering student engagement and cooperative problem-solving, the GI model enhances academic outcomes and cultivates skills essential for lifelong learning and teamwork. However, this study is not without limitations. Factors such as the variability in teacher facilitation, the diversity of student backgrounds, and the specific classroom settings may influence the effectiveness of the GI model. Future

research could explore these variables further and examine the model's long-term impact across diverse educational contexts to refine and expand its applicability.

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