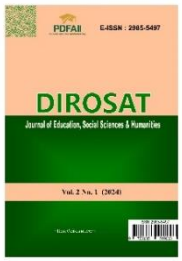

DIROSAT
Journal of Education, Social Sciences & Humanities
Journal website: https://dirosat.com/

ISSN : 2985-5497 (Online)
DOI: https://doi.org/10.58355/dirosat.v3i2.140

Vol. 3 No. 2 (2025)
pp. 254-266

Research Article

Investigating Junior High School Students' Scientific Thinking Ability in Understanding Global Warming

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Received : April 15, 2025
Revised : May 17 , 2025
Accepted : June 19, 2025
Available online : July 17, 2025

How to Cite: Nur Rahmah, Mohammad Jamhari, Ratman, & Sulastriani. (2025). Investigating Junior High School Students' Scientific Thinking Ability in Understanding Global Warming. *DIROSAT: Journal of Education, Social Sciences & Humanities*, 3(2), 254–266. https://doi.org/10.58355/dirosat.v3i2.140

Abstract. Science education in junior high school plays a crucial role in developing students' scientific thinking, particularly in understanding global issues like global warming. This study aims to assess the scientific thinking abilities of seventh-grade students at three state junior high schools in Palu City, using a descriptive approach and a test based on seven aspects of scientific thinking as defined by García-Carmona (2023). The findings reveal that approximately 80% of students showed progress in scientific thinking, with 12% achieving a competent level and 8% remaining in the beginner category. However, their understanding of scientific information from discourse and graphics averaged only

26%. Overall, students demonstrated developing scientific thinking skills, which could enhance their comprehension of scientific concepts, especially related to everyday experiences and environmental issues shared on social media. The role of teachers is essential in guiding students to understand and critically evaluate scientific information, such as articles on global warming. The study recommends developing interactive, problem-based teaching strategies to further improve students' scientific thinking skills. Future research should explore the role of media technology, teachers, and parents in supporting the development of scientific thinking regarding natural phenomena to advance science education in Palu and its surrounding areas.

Keywords: Science education, scientific thinking and global warming

INTRODUCTION

Science education at the junior high school level has a very important role in shaping students' scientific thinking skills. Scientific thinking includes various aspects such as observation, hypothesis formation, experimentation, data analysis, and logical inference. This ability is very important in understanding complex natural phenomena, such as global warming, which is one of the biggest environmental issues in the 21st century. The phenomenon of global warming involves various aspects, such as technology, society, and education, which are constantly evolving and require training that involves the development of metacognition, logic, and analytical reasoning (Goldmeier & Mota, 2023:7). Scientific thinking ability is a high-level thinking skill that students must have in the era of global competition to overcome various problems (A Suryansyah, Kastolani, & Somantri, 2021:1).

Scientific thinking can be defined as an intellectual process that involves conscious search for information, hypothesis formation, observation, pattern recognition, and inference (Jirout, 2020:2). The process of developing scientific thinking includes basic skills in science that are often used in research-based learning. García-Carmona (2023:1) identified seven important aspects of scientific thinking, which include observation, pattern recognition, hypothesis formation and testing, and the ability to evaluate and share information collaboratively.

According to Kuhn et al. (2008), there are three aspects of scientific thinking that are important for students: strategic aspects, understanding the epistemology of science, and ability in scientific arguments. In this case, students must be able to consider existing evidence and see science as a social argument, and play a role in building scientific arguments. Therefore, it is very important for educators to provide guidance to students in exploring scientific evidence systematically (Osterhaus et al., 2021).

This study aims to measure the scientific thinking ability of seventh grade students at SMP Negeri Palu City in understanding the phenomenon of global warming. In addition, this study will identify factors that influence students' scientific thinking skills and provide recommendations to improve the quality of science education to make it more effective and relevant. It is hoped that this research will not only contribute to the development of science, but also provide practical recommendations to improve the quality of science education in Palu City and

surrounding areas, so that students are better prepared to face the challenges of the 21st century, especially related to global warming.

RESEARCH METHODS

The research design used in this research is descriptive. Descriptive research design to describe the level of students' scientific thinking abilities. In the descriptive research design, students' level of understanding is measured using a scientific thinking ability test, which is presented in percentage form. The research population was state junior high school (SMP) students in the city of Palu. The sampling technique is probability sampling with a random sample type based on area (cluster random sampling). The samples for this research were SMPN 2 Palu with 29 students, SMPN 10 Palu with 21 students, and SMPN 12 Palu with 16 students, totaling 66 students. The school was chosen because of its location in the city of Palu.

Table 1. Research sample

School name	Location	Class	Number of students (people)
SMPN 2 Palu	Kec. Palu timur	VII	29
SMPN 10 Palu	Kec. Palu barat	VII	21
SMPN 12 Palu	Kec. Mantikulore	VII	16
Amount			66

The instrument used in the research was a test. The data collection technique is in the form of a test, where a standard assessment test is carried out to measure students' performance regarding scientific thinking abilities. Interviews are carried out by selecting several students who will be interviewed to obtain information about their experience taking tests. In this research, students' scientific thinking abilities were measured using a test instrument with global warming material, which was developed based on aspects of scientific thinking abilities by García-Carmona (2023). Global warming material is taught in class VII in the independent curriculum in the even semester. There are seven aspects of scientific thinking contained in the test, namely: observe and categorize what has been observed; recognize patterns; create and test hypotheses; think about cause and effect; build explanations from evidence; be aware of and control one's own thinking (the meta process); and evaluate, share, collaborate, and think about the information. The scientific thinking ability test assessment technique consists of five questions in the form of an essay test. The previous test was tested on 20 class VII students at SMPN 9 Palu, and the reliability was calculated at 0.67 using Cronbach's alpha, so based on the r table with 5 questions, the 5% significance level was 0.44. So, if the calculated r value is greater than the r table, it can be concluded that the scientific thinking test instrument is reliable or consistent for measuring students' scientific thinking ability tests. The test is then analyzed to categorize the level of scientific thinking ability. The level of development of students' scientific thinking abilities is known from the scientific thinking ability test scores, with assessment criteria consisting of a score of 1–5. As for

evaluating student performance on each indicator, a numerical assessment is carried out ranging from 1 to 5, which reflects different levels of competency (Salahova, 2023:18), namely: minimal, emerging, developing, proficient, and advanced (advanced).

Table 2. Level of development of students' scientific thinking abilities (Salahova, 2023).

No	Score Range	Category
1	0-18	Novice Thinker
2	19-36	Developing Thinkers
3	37-54	Competent Thinker
4	55-72	Proficient Thinker
5	73-90	Expert Thinker

RESULTS AND DISCUSSION

Results

The scientific thinking abilities of students at SMPN 2 Palu can be seen in the following percentages:

Table 3. Results of scientific thinking ability tests for class VII students at SMPN 2 Palu

No.	Students	Question					Score obtained	Criteria for scientific thinking ability
		1	2	3	4	5		
1	Student 1	1	1	1	1	1	28	Developing Thinkers
2	Student 2	1	1	2	2	1	24	Developing Thinkers
3	Student 3	1	1	2	1	1	28	Developing Thinkers
4	Student 4	1	1	2	1	2	44	Competent Thinker
5	Student 5	2	2	2	2	3	24	Developing Thinkers
6	Student 6	1	1	1	1	2	40	Competent Thinker
7	Student 7	2	2	2	2	2	40	Competent Thinker
8	Student 8	2	2	2	2	2	24	Developing Thinkers
9	Student 9	1	1	1	1	2	36	Developing Thinkers
10	Student 10	2	1	2	2	2	36	Developing Thinkers
11	Student 11	2	2	2	2	1	32	Developing Thinkers
12	Student 12	2	2	1	2	1	20	Developing Thinkers
13	Student 13	1	1	1	1	1	24	Developing Thinkers
14	Student 14	1	1	1	1	2	40	Competent Thinker
15	Student 15	2	2	2	2	2	36	Developing Thinkers
16	Student 16	2	2	2	1	2	32	Developing Thinkers
17	Student 17	1	2	2	1	2	24	Developing Thinkers
18	Student 18	1	1	1	1	2	32	Developing Thinkers
19	Student 19	2	1	1	2	2	40	Competent Thinker
20	Student 20	2	2	2	2	2	36	Developing Thinkers
21	Student 21	2	2	2	1	2	32	Developing Thinkers
22	Student 22	1	2	2	1	2	24	Developing Thinkers
23	Student 23	1	1	1	1	2	32	Developing Thinkers
24	Student 24	2	2	1	1	2	28	Developing Thinkers

25	Student 25	1	1	2	1	2	36	Developing Thinkers
26	Student 26	2	2	1	2	2	36	Developing Thinkers
27	Student 27	1	1	3	2	2	32	Developing Thinkers
28	Student 28	1	2	1	2	2	40	Competent Thinker
29	Student 29	2	2	2	2	2	20	Developing Thinkers
Total score		43	44	47	43	53		
Maximum score		145	145	145	145	145		
Acquisition score		30	30	32	30	37		

The test results on the scientific thinking abilities of students at SMPN 10 Palu are as follows:

Table 4. Results of scientific thinking ability tests for class VII students at SMPN 10 Palu

No.	Students	Question					Score obtained	Criteria for scientific thinking ability
		1	2	3	4	5		
1	Student 1	1	1	0	0	0	8	Novice Thinker
2	Student 2	1	1	1	2	2	28	Developing Thinkers
3	Student 3	1	1	1	2	1	24	Developing Thinkers
4	Student 4	1	1	1	1	1	20	Developing Thinkers
5	Student 5	1	1	1	1	2	24	Developing Thinkers
6	Student 6	1	1	1	1	2	24	Developing Thinkers
7	Student 7	1	1	1	2	2	28	Developing Thinkers
8	Student 8	2	2	2	3	3	48	Competent Thinker
9	Student 9	1	1	1	2	2	28	Developing Thinkers
10	Student 10	1	1	1	2	2	28	Developing Thinkers
11	Student 11	1	1	1	1	2	24	Developing Thinkers
12	Student 12	1	1	1	1	1	20	Developing Thinkers
13	Student 13	1	1	1	1	1	20	Developing Thinkers
14	Student 14	1	2	1	1	1	24	Developing Thinkers
15	Student 15	1	1	1	2	2	28	Developing Thinkers
16	Student 16	2	1	1	1	1	24	Developing Thinkers
17	Student 17	1	1	0	1	1	16	Novice Thinker
18	Student 18	1	1	0	1	1	16	Novice Thinker
19	Student 19	1	1	1	1	2	24	Developing Thinkers
20	Student 20	1	1	1	1	1	20	Developing Thinkers
Total score		23	23	18	27	30		
Maximum score		100	100	100	100	100		
Acquisition score		23	23	18	27	30		

The scientific thinking abilities of class VII students at SMPN 12 Palu are:

Table 5. Results of scientific thinking ability tests for class VII students at SMPN 12 Palu

No.	Students	Question					Score obtained	Criteria for scientific thinking ability
		1	2	3	4	5		
1	Student 1	1	1	2	1	1	24	Developing Thinkers
2	Student 2	0	1	1	1	1	16	Novice Thinker
3	Student 3	1	1	2	1	1	24	Developing Thinkers
4	Student 4	1	1	2	1	2	28	Developing Thinkers
5	Student 5	0	1	2	1	1	20	Developing Thinkers

6	Student 6	1	1	1	1	2	24	Developing Thinkers
7	Student 7	2	1	2	2	2	36	Developing Thinkers
8	Student 8	1	1	2	1	2	28	Developing Thinkers
9	Student 9	2	1	2	2	2	36	Developing Thinkers
10	Student 10	1	0	2	2	2	28	Developing Thinkers
11	Student 11	1	1	2	2	2	32	Developing Thinkers
12	Student 12	1	2	2	2	1	32	Developing Thinkers
13	Student 13	1	1	2	1	1	24	Developing Thinkers
14	Student 14	2	2	2	1	2	36	Developing Thinkers
15	Student 15	2	2	2	2	2	40	Competent Thinker
16	Student 16	2	2	2	1	1	32	Developing Thinkers
Total score		19	19	30	22	25		
Maximum score		80	80	80	80	80		
Acquisition score		24	24	38	28	31		

Based on the test results obtained from 3 State Junior High Schools in 3 areas in the city of Palu as a whole as follows:

Figure 1. Total results obtained from students' scientific thinking ability tests

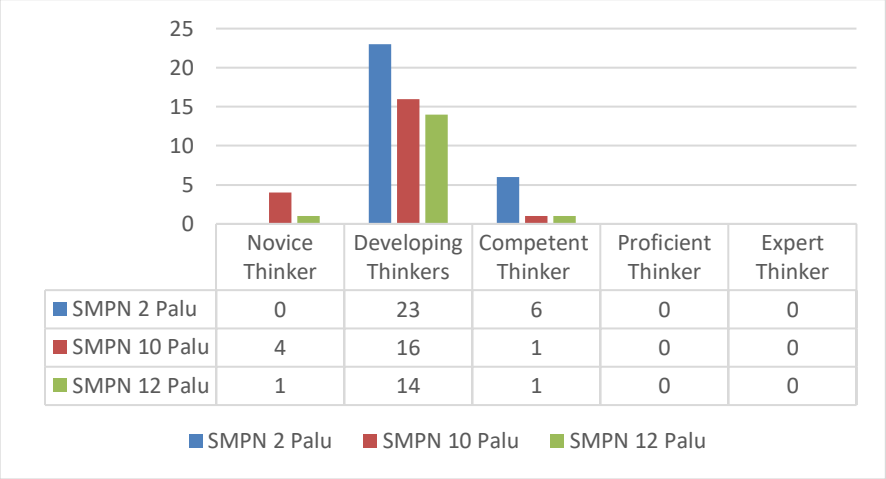
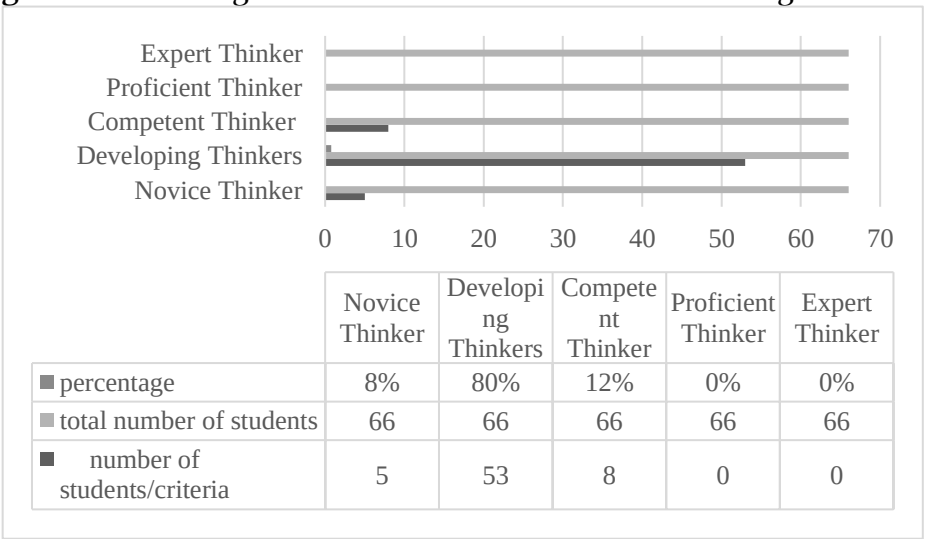


Figure 2. Percentage of students' overall scientific thinking test results



The percentage of students' ability to understand question indicators that contain aspects of scientific thinking as a whole is as follows:

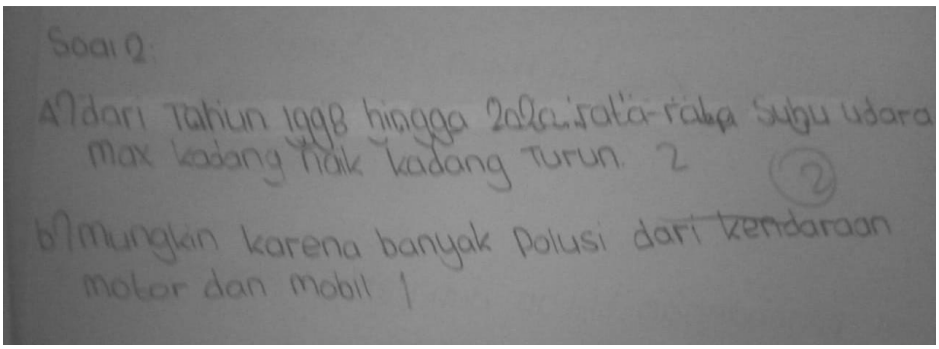
Table 6. Percentage and criteria for scientific thinking on the scores obtained by all students for each question indicator

School	Question				
	1	2	3	4	5
SMPN 2	30	30	32	30	30
SMPN 10	23	23	18	27	23
SMPN12	24	24	38	28	24
Percentage (%)	26	26	29	28	26
Criteria	Developing Thinkers	Developing Thinkers	Developing Thinkers	Developing Thinkers	Developing Thinkers

DISCUSSION

Based on the overall test results, it was found that 12% of students had competent scientific thinking abilities, 80% had developed scientific thinking abilities, 8% had beginner scientific thinking abilities, and 0% were unable to think scientifically according to the criteria of advanced and expert. This shows that 12% of all students have been able to develop scientific thinking skills by showing the development of abilities in several components assessed. As many as 80%, or the majority of students, are developing thinking abilities. Students have made progress in developing scientific thinking skills by showing development of abilities in several components assessed. 8% of the results show that students have beginner thinking skills, which are still very low in understanding the components being assessed. The ability to think according to the criteria for proficient and expert thinking does not yet exist where students are not consistent in fulfilling the assessment components, namely being able to think critically, having a high and deep understanding, and being able to solve problems in a complex scientific context based on investigations and high learning experiences. Table 6 shows an analysis of students' abilities for each question item according to indicators containing seven aspects of scientific thinking (García-Carmona, 2023). The 7 aspects are spread across all the questions asked, and the results show that 26%, or the low category, are found in the questions. 1 and 2 have an understanding of observing and categorizing, recognizing patterns, analyzing cause and effect, and building explanations from evidence in the low category. Most students only observe patterns formed by graphs without understanding how these patterns are formed due to the variables contained in the graph, so they are still very weak at providing relevant arguments related to the problems presented.

Figure 3. Students' answers in explaining graphs related to the phenomenon of global warming



Learners appear to be weak in understanding the reading and analyzing the causal relationship of information and lack of understanding the explanation of the scientific evidence presented so that the answers only rewrite the existing discourse. 33% or low category in showing the ability to think critically and solve problems on scientific phenomena. Critical thinking skills are one of the factors that can improve reading skills (Paige, Rupley & Ziglari, 2024). Learners mostly lack understanding of the scientific discourse presented so that they are still weak in explaining cause and effect and compiling arguments based on scientific evidence from the ability to understand the context of the problem presented so that it results in problem solving that is still relatively low. Interviews were conducted with students where the results concluded that the difficulty in understanding graphical problems was that they were not used to being given by teachers in learning. The problems given are mostly still in the form of known and asked without any stimulus to improve thinking skills through graphs. The statements of some students when asked about their experiences when working on problems that contain graphical images through interviews. The student interview statements are as follows: "*The problem is difficult to understand and the test given is very difficult to understand*". As for other statements: "*the problems given by the school have never had graphic images, so I don't understand*". The difficulty in working on problems that present graphs is how to observe and categorize and recognize patterns formed due to the influence of variables. In question no. 3 there are 29% or low category in observing, making hypotheses, analyzing causal relationships, explaining and solving problems from information presented in scientific discourse. The results of interviews and tests given show students' weak ability to understand data and graph-based problems. Students' difficulties in explaining and connecting data on scientific phenomena such as global warming.

Problem solving that involves the ability to think also involves the ability to combine concepts into good reasoning. How students combine concepts and reasoning depends on how well they associate exactly what is observed (Rahmah, 2021). Combining intuition and reasoning is very useful in solving problems better (Rahmah, et.al., 2020). The difficulties faced in questions number 2, 3, 4 and 5 where students are asked to read and understand the discourse explanation then be able to

formulate hypotheses and plan solutions in problem solving through critical thinking and evaluation. Learners' statements that: "I have read the discourse, but I don't understand what cause and effect are, so I just remember". This statement shows that learners not only answer through understanding the reading but also the experience included in the answer which is still less relevant. The next question was whether the graphs and discourse helped learners in working on the questions presented. The explanation that "in my opinion the text and graphics are very helpful in working on problems, but it is difficult to understand the meaning". Based on the explanation of the results of interviews related to the experience of students in working on problems, it can be concluded that the ability to understand concepts through text and graphics is very important in stimulating the scientific thinking ability of students. One of the factors that affect students' focus and understanding in reading discourse is basic skills related to understanding in distinguishing symbols, letters and numbers (Muhlisin, et.al., 2024). Understanding of concepts to be able to understand cause and effect and provide explanations based on relevant evidence is important to be developed as an individual's capital in developing their cognitive abilities. Understanding the concept of cause and effect involving students' critical thinking skills is also important in managing digital information and assessing the credibility of information sources obtained from the social environment.

The ability to understand discourse related to scientific information is how readers engage with multimodal texts such as containing graphs, numbers, symbols and others. According to Tang, Lin & Kaur (2022:11) that factors that influence this knowledge are background knowledge, emotional involvement, cognitive dissonance arising from conflicting viewpoints, argument skills and the influence of visual images. In addition, reading ability and information integration strategies in graphics depend on the characteristics of each student (Guo, et.al., 2020). Concept understanding is the ability of students to understand concepts and restate these concepts in their own language independently and construct their knowledge based on their learning experiences (Harmadji, et.al., 2023). The overall research results show that students have developed scientific thinking skills so that they have the potential to improve understanding and application of scientific concepts through scientific thinking that contains concepts that are presented contextually both daily learning experiences and environmental problems that are trending on social media.

The research findings show that scientific thinking can be done by teachers through scientific learning activities. The developed test is very good in measuring the scientific thinking ability of students through the presentation of scientific information obtained from discourse and graphs in scientific articles relevant to global warming material. Global warming material is material found in class VII in science learning and is also a world trend related to environmental problems. It is intended that students can understand scientific information that can be found in social media and then be able to critically argue and evaluate the content of discourse scientifically. Science learning should also be designed in a differentiated manner that considers student characteristics and maximizes the development of scientific reasoning (Ningtyas, et.al., 2024). The importance of developing effective learning strategies to improve students' scientific thinking skills, especially in the context of

understanding global warming. The development of graphic literacy-based learning is needed to support student success in the STEM field (Rosenblum, Cheng & Beal, 2018). However, graphic comprehension skills require explicit, contextualized and reflective teacher teaching support (Gardner, Angra & Harsh, 2024). These skills can be done through reading and critically evaluating complex data, building data-based arguments and engagement in science practices. In addition, the importance of learning models that integrate scientific phenomena problems with interdisciplinary approaches in producing graphical visualizations that support understanding, analysis and scientific decision making based on complex data (Pierro, et.al., 2021:8). Therefore, teachers can consider interactive and problem-based approaches to stimulate students' critical and creative thinking about environmental solutions. In addition, it is important to incorporate scientific context related to natural phenomena presented in scientific information to be further displayed in learning activities to improve students' critical thinking and argumentation skills. Future research can focus on developing and evaluating learning strategies that are more effective in improving students' scientific thinking skills, especially related to global warming. In addition, consider the role of external factors, such as technological media support, interdisciplinary scientific phenomena problems and learning approaches as well as the role of teachers and parents in increasing students' interest and motivation to be critical of problems related to natural phenomena. Thus, this follow-up research can provide deeper insights for the development of science education in Palu City and its surroundings.

CONCLUSION

This study shows that most of the seventh grade students in several public junior high schools in Palu City are still in the development stage of scientific thinking skills. Only about 12% of learners have reached the competent level in scientific thinking, while the majority, 80%, are still in the developing process and about 8% are still at the beginner level. Interview results show that learners have difficulties, especially in understanding graphs and scientific texts, indicating the need for improved learning approaches that are more in-depth and inclusive. These results are expected to help science education in SMP Negeri Palu City make a greater contribution in preparing learners for the complex challenges related to global warming and other environmental issues in the future, particularly in improving skills relevant to the 21st century era and society 5.0 where balancing solutions to social and environmental problems is crucial. Based on the description of the importance of scientific thinking in understanding scientific phenomena, future research can focus on developing and evaluating more effective graph-based learning strategies, especially in integrating data literacy with understanding scientific phenomena such as global warming. In addition, it is important to explore the role of digital technology and social media in improving students' scientific literacy, as well as examining the effect of teacher training on improving students' scientific thinking skills. Therefore, to improve learners' scientific thinking skills related to global warming, some practical recommendations are needed. First, teachers can adopt more interactive and problem-based learning approaches to stimulate learners' critical and analytical

thinking. Second, the integration of more exercises in understanding scientific graphs and texts in the curriculum can help learners overcome their difficulties in interpreting scientific information. Third, active support from teachers and the school environment in guiding learners to develop systematic scientific thinking skills is essential.

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