Jenius: Journal of Education Policy and Elementary Education Issues

https://ejournal.uinsaid.ac.id/index.php/jenius

Science Literacy and Critical Thinking Skills of Elementary School Students: A Correlation Study

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ARTICLE INFO

Article History
Received: 17 November 2024
Accepted: 03 December 2024
Published: 23 December 2024

Keywords:
Critical Thinking Skills; Literacy; Science Literacy

ABSTRACT

Scientific literacy includes students' ability to understand scientific concepts, apply that knowledge to solve problems and make decisions based on scientific information. Meanwhile, critical thinking skills involve analysing, evaluating, and synthesising information logically. This study aims to analyse scientific literacy skills, critical thinking skills, and the relationship between the two in elementary school students. The research method used is a quantitative approach with a correlational type. The population in the study involved 68 students of grade V MI Muhammadiyah Trangsan, so a sample of 58 students was obtained using the Slovin formula. The sampling technique used was simple random sampling. Data were collected through essay tests of scientific literacy and critical thinking skills on the water cycle material. The results showed an average value of scientific literacy of 62.71, which is in the moderate category; an average value of critical thinking skills of 71.93, which is in the moderate category; and a correlation coefficient value of 0.617, which indicates a fairly strong positive relationship. This result means that the higher the students' scientific literacy skills, the better their critical thinking skills. A simple linear regression test shows R2 = 0.381, meaning that scientific literacy factors influence 33.8% of critical thinking skills, while other factors influence the remaining 66.2%. This finding indicates the importance of strengthening scientific literacy in learning to improve students' critical thinking skills.

INTRODUCTION

In an era of globalisation that is full of challenges and rapid change, scientific literacy is one of the important competencies that every individual must have (Fortus et al., 2022; Turiman et al., 2012) and can be optimised starting from elementary school (Kähler et al., 2020). Scientific literacy includes an understanding of basic scientific concepts and the ability to apply them to

solve everyday problems and make decisions based on scientific information (Fortus et al., 2022; Sharon & Baram-Tsabari, 2020). This competency is an important foundation in creating a generation that can face modern world problems critically and innovatively (Howell & Brossard, 2021; Valladares, 2021).

However, in reality, students' scientific literacy in Indonesia tends to be low based on the results of the 2022 Programme for International Students Assessment (PISA) study, which showed a decline internationally due to the pandemic. Regarding scientific literacy, Indonesia's ranking rose six times compared to the previous year. Even so, Indonesia's score fell by 13 points, almost equivalent to the international average, which fell by 12 points (OECD, 2024). The low scientific literacy of students is also supported by the fact of documentation data from the results of the 2022 Indonesian Madrasah Competency Assessment (AKMI) at MI Muhammadiyah Trangsan. This assessment was conducted on grade V students, involving 43 students. The results showed that eight students were at the "Basic" achievement (students' ability to understand basic scientific literacy concepts but were not yet able to apply them adequately), 11 students were at the "Skilled" achievement (demonstrating understanding and application of science in simple situations, although not yet able to handle complex problems), and 24 students were at the "Proficient" achievement (the ability to understand, apply, and integrate scientific concepts in various contexts, but have not yet achieved high-level thinking competencies).

One of the factors that influences low scientific literacy is critical thinking skills (Dayelma et al., 2019). Scientific literacy skills cannot be separated from critical thinking skills because both support each other in understanding scientific phenomena in depth (Valladares, 2021). Critical thinking skills play an important role in helping students analyse information (Alsaleh, 2020; Goodsett, 2020), evaluate data (Erdogan, 2019), and solve problems logically (Mahanal et al., 2019), all of which are key elements in scientific literacy. Low critical thinking skills can hinder students' ability to understand scientific concepts and apply them in everyday life situations (Alditia et al., 2021; S. L. E. W. Fajari & Chumdari, 2021; Magarelli, 2024). This research shows that increasing scientific literacy needs to be balanced with developing critical thinking skills through appropriate learning strategies (Abrami et al., 2015; Heard et al., 2020). Based on the results of interviews with teachers, the teacher often uses the lecture method, and it is still not optimal in implementing scientific-based learning because they still do not understand the concept of scientific learning. This condition indicates the need for training and mentoring for teachers in understanding and implementing scientific-based learning effectively

(Anggrella et al., 2023). Scientific learning, which emphasises the process of observation, data collection, analysis, and conclusions, is very relevant to improving students' scientific literacy and critical thinking skills (Sutiani et al., 2021).

Based on the problems in science learning, an analysis of the relationship between students' critical thinking skills and scientific literacy skills is needed. Research related to the relationship between these two aspects has been previously conducted by Dayelma et al. (2019) at SMK Pekanbaru in chemistry subjects. The study found a positive relationship between critical thinking skills and students' scientific literacy at the secondary education level. In contrast to the research by Dayelma et al. (2019), this study focused on elementary education, namely grade V students of MI Muhammadiyah Trangsan, with more general subjects in science (Dayelma et al., 2019). This difference provides space to explore the relationship dynamics between critical thinking skills and scientific literacy at the elementary education level, which has different student characteristics and learning methods.

Therefore, it is important to research the relationship between elementary school students' scientific literacy skills and critical thinking skills to provide more specific and relevant insights regarding the development of these two abilities in elementary school students.

METHOD

The research approach is quantitative with a correlational type. This study aims to determine the relationship between variables, the level of relationship, and the influence of scientific literacy on critical thinking skills. This study was conducted at MI Muhammadiyah Trangsan, Gatak District, Sukoharjo Regency. The population involved all MI Muhammadiyah Trangsan fifth-grade students, with a total of 68 students. The sampling technique used was a simple random sampling technique. The number of samples was determined using the Slovin formula with a 5% error rate, so a sample of 58 students was obtained.

Data was collected using an essay test to measure scientific literacy and critical thinking skills on the water cycle material in elementary school science learning. Indicators of scientific literacy skills from the competency domain, according to PISA 2018. The scientific literacy instrument consists of several domains consisting of 8 question items with the grid in Table 1 as follows:

Table 1. Exam Content Outline of Scientific Literacy-Based Instruments

Context domain	Content domain	Competency domain	Question indicator	Question number
Personal	Natural Resources (personal consumption)	Evaluating and designing scientific research	Presented with a reading text about water for everyday needs, students can evaluate data related to the pH content of water correctly.	1
Personal	Natural Resources (personal consumption)	Interpreting data and evidence	Presented with reading text about water for everyday needs, students can interpret data and scientific evidence correctly	2
Local/ National	Natural Resources (energy supply)	Explaining scientific phenomena	Presented with a reading text related to the clean water crisis, students can explain scientific phenomena based on the reading text correctly	3
Local/ National	Natural Resources (energy supply)	Interpreting data and evidence	Presented with reading text related to the clean water crisis, students can correctly identify assumptions related to the lack of clean water	4
Local/ National	Environmental Quality	Explaining scientific phenomena	Presented with a reading text on water pollution, students can explain scientific phenomena based on the text correctly	5
Local/ National	Environmental Quality	Evaluating and designing scientific research	Presented with a reading text on water pollution, students can appropriately evaluate and design scientific research based on the text.	6
Local/ National	Environmental Quality	Interpreting data and evidence	Presented with a reading text on water pollution, students can interpret data and evidence based on the text correctly	7
Local/ National	Environmental Impact	Explaining scientific phenomena	Presented with a reading text on water conservation, students can correctly explain scientific phenomena based on the text.	8
Number of questions				8

Critical thinking skills are measured using an instrument grid with indicators adopted from the Ennis (2001) source, which are shown in Table 2 below:

Table 2. Exam Content Outline of Critical Thinking Skills-Based Instruments

Critical thinking indicators	Description	Question indicator	Question number
Providing a simple explanation	Focusing questions, analysing arguments or points of view, asking and answering challenging questions	Students can correctly analyse the differences in seasons associated with the water cycle process.	1
Provide further explanation	Define terms and evaluate definitions, identify assumptions	Given a statement about the requirements of water, students can correctly identify the suitability of water for human consumption	2

Critical thinking indicators	Description	Question indicator	Question number
Provide further explanation	Define terms and evaluate definitions, identify assumptions	Presented with a picture of water pollution in a river, students can identify the causes of water pollution in the river correctly	3
Building basic skills	Assess the credibility of a source, observe and evaluate the results of observations	Presented with data related to the decline in the availability of clean water in Indonesia, students can analyse the causes of the decline in the availability of clean water correctly	4
Building basic skills	Assess the credibility of a source, observe and evaluate the results of observations	Presented with data related to the decline in forest loss, students can analyse the causes of forest loss and its effects on the water cycle correctly	5
Making inferences	Making deductions and evaluating the results of deductions, making inductions and evaluating the results of inductions, and making and deciding	Students can make conclusions and hypotheses about the relationship between conservation and the availability of clean water for the community.	6
Making inferences	Making deductions and evaluating the results of deductions, making inductions and evaluating the results of inductions, and making and deciding	Students can make conclusions and hypotheses if an area does not have a proper water catchment area	7
Setting strategy and tactics	Determine actions and interact with others.	Students can formulate various alternative solutions for disposing of waste in rivers appropriately	8
Number of questions			8

(Ennis, 2018)

Based on the validity and reliability test results, each item on scientific literacy and critical thinking skills was declared valid and reliable. The results of the reliability test are presented in Table 3.

Table 3. Results of the Reliability Test of the Scientific Literacy and Critical Thinking Skills Question Instruments

Variable	Cronbach's alpha value	Number of question items
Scientific literacy	0, 668	8
Critical thinking skills	0, 817	8

The collected data was subjected to descriptive and parametric statistical tests. Descriptive statistical tests were conducted to determine the general description or basic characteristics of the data used in the research and information related to critical thinking skills and scientific literacy analysis.

Hypothesis testing using parametric statistics, Pearson correlation test and simple linear regression. The Pearson correlation test measures the linear relationship between the two

variables, whether there is a significant relationship and how strong the relationship is. This analysis is carried out with the assumption that the data is normally distributed and has a linear relationship. Meanwhile, the Simple linear regression test determines the effect of independent variables, namely scientific literacy skills, on dependent variables, namely critical thinking skills (Cohen et al., 2018).

RESULTS AND DISCUSSION

This study analyses the relationship between scientific literacy skills and critical thinking skills in grade V students of MI Trangsan. Scientific literacy and critical thinking skills are two important aspects of science education that are interrelated and influence each other.

Before presenting the results of further analysis, the following table shows the calculation of descriptive statistics for students' scientific literacy and critical thinking skills. The descriptive statistics shown in Table 4 provide an overview of the distribution of data and the level of student's abilities in both aspects.

Table 4. Descriptive Statistical Calculations of Scientific Literacy Skills and Critical Thinking Skills

Descriptive Statistics	Scientific literacy	Critical thinking skills
Mean	62,71	71,93
Median	63	75
Modus	75	85
Standar Deviasi	21,851	17,421
Lowest Value	13	35
The highest score	100	95

Based on Table 4, it can be seen that the average (mean) score of students' scientific literacy is 62.71, which indicates that most students are in the category of scientific literacy skills that still need improvement. Meanwhile, the average score of students' critical thinking skills is 71.93, which indicates that the level of students' critical thinking skills is in a better category than scientific literacy.

This difference between the scores of science literacy and critical thinking skills may indicate that although some students have a fairly good understanding of science concepts, they may still have difficulty applying critical thinking skills in more complex situations. This result can be seen from the higher value of the critical thinking skills mode (85) compared to science literacy (75), indicating that more students scored higher in critical thinking skills than science

literacy.

In addition, the standard deviation for scientific literacy (21.851) was larger than that for critical thinking skills (17.421), indicating a greater variation in scientific literacy skills among students than critical thinking skills. This statement could mean that some students have very low scientific literacy skills, and critical thinking skills are more evenly distributed among students.

The lowest score for science literacy was 13, while the highest score was 100, indicating a fairly wide range in student achievement. This result indicates a fairly significant difference in understanding basic science concepts. For critical thinking skills, the lowest score was 35, and the highest score was 95, indicating that most students could achieve a fairly good level of critical thinking skills, although some still needed improvement.

Next, Table 5 and Table 6 show the categorisation of the results of the students' science literacy and critical thinking skills tests. This categorisation is used to group student scores based on intervals calculated from the mean (M) and standard deviation (SD), which provides an overview of the distribution of scores among students.

Table 5. Categorisation of Scientific Literacy Test Results

Category	Interval	Frequency	Percentage
Very low	X≤ M-1,5SD X ≤ 30	6	10%
Low	M-1,5SD < X ≤ M - 0,5SD 30 < X ≤ 52	17	30%
Currently	M - 0,5SD < X ≤ M + 0,5SD 52 < X ≤ 73	8	14%
High	M + 0,5SD < X ≤ M + 1,5SD 73 < X ≤ 95	24	41%
Very high	M + 1,5SD < X 95 < X	3	5%

Table 5 shows that students who get the very low category are 10%, the low category is 30%, the medium category is 14%, the high category is 41%, and the very high category is 5%. Based on the categorisation of science literacy scores, students with the high category get the highest percentage. However, based on the overall average student score of 62.71, it is included in the medium category. This result is because students are not used to solving questions related to science literacy, in line with research from Zuhra et al. (2021), which states that the factor that causes students' science literacy skills in the medium category is that students can determine problems but have not yet solved them (Zuhra & Arifiyanti, 2021).

Table 6. Categorisation of Critical Thinking Skills Test Results

Category	Interval	Frequensi	Percentage
Very low	X≤ M-1,5SD X ≤ 46	7	12%
Low	M-1,5SD < X ≤ M - 0,5SD 46 < X ≤ 63	10	17%
Currently	M - 0,5SD < X ≤ M + 0,5SD 63 < X ≤ 80	18	31%
High	M + 0,5SD < X ≤ M + 1,5SD 80 < X ≤ 97	23	40%
Very high	M + 1,5SD < X 97 < X	0	0%

Table 6 shows that students who get the very low category are 12%, the low category is 17%, the medium category is 31%, the high category is 40%, and the very high category is 0%. Based on the categorisation of critical thinking scores, students with the high category get the highest percentage, but if based on the average score of students as a whole, 71.93, it is included in the medium category. This result is because most students have a range of scores not far from the average. Hence, the distribution of scores is more concentrated around the medium category even though the percentage of the high category looks dominant.

Not all students are in the high category. This can be caused by students' limitations in applying critical thinking skills to more complex or challenging situations (Basri et al., 2019), which are not optimally facilitated in the classroom learning process (Alsaleh, 2020).

The analysis results of Tables 5 and 6 show that most students (41%) have high scientific literacy skills. In comparison, their critical thinking skills tend to be more evenly distributed, with most students (40%) in the high category. This result shows that although many students show a good level of scientific literacy, the development of critical thinking skills of fifth-grade students can still be further improved.

Students in the low or very low category in both tests indicate challenges in learning that must be addressed immediately through a more effective approach and targeted strategies in improving scientific literacy and critical thinking skills. Based on previous research, learning that can activate students during the learning process so that they train their critical thinking skills and scientific literacy is with a scientific approach, such as the PBL learning model (Wong et al., 2021), PjBL, inquiry (Sutiani et al., 2021). In addition, science literacy can also be improved with the STEM approach. To make learning more enjoyable, teachers can integrate learning with

game-based learning (Twiningsih & Elisanti, 2021).

A Pearson correlation analysis was conducted to determine the relationship between scientific literacy skills and critical thinking skills. This analysis aims to identify how strong the relationship between the two variables is in grade V students of MI Muhammadiyah Trangsan. Table 7 below shows the results of the correlation analysis between scientific literacy and critical thinking skills.

Table 7. Correlation Test Results

		Science Literacy	Critical thinking
Science Literacy	Pearson Korelasi	1	0,617**
	Sig. (2-tailed)		0,000
	N	58	58
Critical thinking	Pearson Korelasi	0,617**	1
	Sig. (2-tailed)	0,000	
	N	58	58

Based on Table 7, it can be seen that there is a significant positive relationship between students' scientific literacy skills and critical thinking skills, with a Pearson correlation value of 0.617**. This correlation value indicates a moderate relationship, namely a quite strong relationship but not very high. A significance value (sig.) of 0.000, which is smaller than 0.05, indicates that the relationship between scientific literacy and critical thinking skills is statistically significant. This result means that an increase in students' scientific literacy skills tends to be followed by an increase in critical thinking skills.

These results indicate that developing scientific literacy in the classroom can improve students' critical thinking skills, which are important in solving problems and making decisions based on scientific data. These results align with the research of Dayelma et al. (2019), which shows a relationship between scientific literacy and critical thinking skills (Dayelma et al., 2019). Therefore, learning that integrates these two skills will have a greater impact on academic achievement (Sutiani et al., 2021; Wong et al., 2021).

A simple regression test was conducted to determine how scientific literacy influences students' critical thinking skills. This regression test aims to measure the influence of scientific

literacy on improving critical thinking skills. The following are the regression test results that describe the relationship between the two variables in Table 8.

Table 8. Simple Regression Test Results

Model	Sum of Squares	df	Mean of square	F	Sig.
1 Regresi	6594,462	1	6594,462	34,496	0,000[b]
residu	10705,262	56	191,165		
Total	17299,724	57			

Based on the results of the simple regression test shown in Table 8, it can be seen that the F value of 34.496 with sig. 0.000 (less than 0.05) indicates that this regression model is significant. This result means that scientific literacy significantly influences students' critical thinking skills.

A simple regression equation test was conducted to analyse further scientific literacy's influence on students' critical thinking skills. This test determines how scientific literacy can statistically predict students' critical thinking skills. The following are the results of the regression equation test that measures the relationship between the two variables in Table 9 as follows:

Table 9. Results of Simple Regression Equation Test

Model	Non-standard coefficients		Standard Coefficient	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	41,064	5,560	0,617	7,385	0,000
Science Literacy	0,492	0,084		5,873	0,000

Based on the results of the simple regression equation test presented in Table 9, it can be concluded that scientific literacy significantly influences students' critical thinking skills. From Table 9, the constant value (a) is 41.064, while the trust value (b/regression coefficient) is 0.492, so the regression equation is written as Y = a + Bx

$$Y = 41{,}064 + 0{,}492X$$

So, it can be concluded that the constant of 41.064 means that the consistency value of the participation variable is 41.064. If the value of scientific literacy (X) is zero, then critical thinking skills (Y) are estimated to be 41.064. The non-standard coefficient for scientific literacy is 0.492, which means that every unit increase in the scientific literacy score will increase critical thinking skills by 0.492 units. This result aligns with the research of Kusumastuti et al. (2019), which shows that critical thinking skills influence scientific literacy (Kusumastuti et al., 2019).

Students who can think critically tend to have better scientific literacy because they can analyse scientific information, draw conclusions based on evidence, and connect theory to practice (Vieira & Tenreiro-Vieira, 2016).

Then, a determination coefficient test was conducted to find out how much influence scientific literacy ability has on critical thinking skills. The results of the determination coefficient test can be seen in Table 10.

Table 10. Results of the Coefficient of Determination

Model	R	R squared	Adjusted R squared	Std. estimation error
1	0,617[a]	0,381	0,370	13,826

From Table 10 above, it can be seen that the magnitude of the correlation value or relationship is 0.617. From the output, it is known that the coefficient of determination (R Square) is 0.381, which means that the influence of the scientific literacy ability variable on the critical thinking skills variable is 38.1%. This result shows that scientific literacy is important in optimising critical thinking skills but is not the only factor. This result confirms that integrating scientific literacy into learning will help develop critical thinking skills. However, a more holistic approach is needed to optimise results, which must consider various other supporting factors. There are 61.9% influenced by other factors that are not included in this model.

Based on previous research, the factor that influences critical thinking skills in science learning is students' intrinsic motivation (Berestova et al., 2022; L. E. W. Fajari et al., 2020; Valenzuela et al., 2011)**,** learning experience (Huber & Kuncel, 2016), independent learning (Asmar & Delyana, 2020), science process skills (Fitria, 2021; Wiratman et al., 2023)**,** and innovative learning models (Alsaleh, 2020; Anazifa & Djukri, 2017; Sumarni & Kadarwati, 2020).

Teachers must adopt learning strategies that simultaneously improve scientific literacy and critical thinking skills (Sutiani et al., 2021). Approaches such as inquiry-based learning (Wilke & Straits, 2006), *problem-based learning* (Nargundkar et al., 2014), and project-based learning (Wijayanti & Prodjosantoso, 2021) can be used to provide an in-depth learning experience so that students can understand science concepts while practising critical thinking skills. However, the results of interviews with teachers showed that classroom learning still uses many lecture methods and still finds it difficult to use a scientific-based approach or problem-based learning that can train students' critical thinking skills. Teachers also expressed that the lack of time and resources to design more interactive and challenging learning activities was one of the main obstacles. According to research by Kim et al. (2019), the lack of understanding of the context

of teaching practices will impact the quality and competence of students (Kim et al., 2019).

In addition, the evaluation system in elementary schools needs to cover aspects of science literacy and critical thinking skills more explicitly. However, students tend to be unfamiliar with analytical questions or tasks that require evaluation and synthesis of information, as evidenced by the analysis of the Daily Test questions identified from 30 questions consisting of 15 multiple choice questions, ten fill-in questions and five essay questions, almost 90% still use Low Order Thinking Skill (LOTS) type questions, so that their critical thinking skills have not developed optimally (Basri et al., 2019). Teachers can use evaluation tools in the form of problem-based tests (Shafira & Suratsih, 2023; Sucipta et al., 2023) or projects (Yani et al., 2023) to measure critical thinking skills and HOTS-based evaluation (Karlina & Abidin, 2022; Razak et al., 2021) for students' scientific literacy skills more accurately.

The results of this study indicate the importance of training teachers to implement effective science-based learning. According to research by Anggrella et al. (2023), teachers need to be trained to design learning activities that not only improve understanding of science concepts but also encourage students to analyse, evaluate, and create solutions based on scientific principles (Anggrella et al., 2023).

CONCLUSION

The study results showed that the students' scientific literacy level was mostly in the medium to high category. Likewise, the students' critical thinking skills were mostly high. However, there were still students in the low and very low categories, which indicated a gap in scientific literacy and critical thinking skills. Correlation analysis showed a significant positive relationship between scientific literacy and students' critical thinking skills. The correlation coefficient value of 0.617 indicated a fairly strong relationship. This research shows that increasing scientific literacy directly correlates to increasing critical thinking skills. The results of the simple regression test showed that scientific literacy significantly contributed to critical thinking skills. The determination coefficient of 38.1% indicated that scientific literacy affects critical thinking skills, although other factors outside of scientific literacy also contribute.

These findings emphasise the importance of integrating learning strategies that can simultaneously improve science literacy and critical thinking skills, such as scientific-based learning, project-based learning, or problem-based learning. Teachers need to be supported with adequate training and resources to optimise students' potential in both aspects.

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