RESEARCH ARTICLE

Correlational between: Biological literacy and metacognitive abilities with critical thinking in junior high school students

N. Najmah[a,1,*], R. Rusdi [a,2], Rizhal Hendi Ristanto[a,3]

[a] Biology Education Master Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Jl. R. Mangun Muka Raya, Rawamangun, Kec. Pulo Gadung, East Jakarta City, Special Capital Region of Jakarta 13220, Indonesia

[1]najmahkim09@gmail.com; [2]rusdi@unj.ac.id; [3]rizhalhendi@gmail.com

Abstract: Facing the 21st century which is an educational challenge requires schools to be able to produce students who have biological literacy skills, metacognitive skills and critical thinking skills. The study aims to analyze the relationship between biological literacy skills and critical thinking, analyze the relationship between metacognitive abilities and critical thinking, and analyze the relationship between biological literacy skills and critical thinking. metacognitive abilities with critical thinking. The research was conducted at Public Junior High School 3 Parungpanjang, Bogor. The research sample consisted of 150 class VII students consisting of 8 classes. Critical thinking skills are measured using a critical thinking instrument in the form of essay questions from 6 aspects of critical thinking. Biological literacy is measured using multiple choice questions with 4 levels of biological literacy dimensions. Metacognitive ability is measured using an essay question metacognitive ability instrument developed from 3 metacognitive aspects. The test results show that the average student's biological literacy ability is in the medium category, the student's metacognitive ability is sufficient and the student's critical thinking ability is high. There is a significant relationship between biological literacy and critical thinking but there is no relationship between metacognitive ability and critical thinking, and there is a mutual relationship between biological literacy, metacognitive ability and critical thinking with a correlation value of 0.444 (medium correlation).

Keywords: biological literacy; critical thinking; metacognitive ability

For correspondence:
najmahkim09@gmail.com

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Introduction

Facing the 21st century requires competencies covering the cognitive, interpersonal and intrapersonal domains. Cognitive abilities consist of a person's ability to think, while interpersonal abilities are a person's ability to interact, socialize and communicate (Restu Sagita et al., 2021). Another ability is intrapersonal ability which is part of how someone is able to control themselves, know themselves and be able to have self-confidence. This will give students the intelligence to convey what they know well and wisely (Estalita, 2015). Conventionally, cognitive competence which includes critical thinking, analysis and problem solving can be expected to be a key indicator of success (Nuraini, 2017). Critical thinking skills are an organized process that allows students to evaluate the evidence, assumptions, logic, and language underlying other people's thinking (William, 2010). Critical thinking skills show the development of cognitive proficiency which is very important and must be developed, because it is integrated with everyday life (Du et al., 2013). Critical thinking skills influence students to focus, look for reasons, and analyze problems (Ristanto et al., 2022). In the critical thinking process, students are trained to understand each problem from the point of view and things that influence the problem as little as possible (nuance), understanding nuances in critical thinking skills involves active functional literacy, namely how students fully understand an argument/problem and are able to express it. complete and coherent ideas that students have. Literacy skills are students' ability to apply scientific concepts in everyday life (Zuhara et al., 2019). Biological literacy is the ability to use scientific inquiry to understand and recognize biological issues in society and integrate these ideas into decision making and communicating results to others (McBride et al., 2013). Biological literacy can be improved through

developing skills in problem-solving aspects of everyday life (Lederman et al., 2013). The low level of students' biological literacy skills is caused by the lack of student involvement in the learning process, students are trained to only listen and master the material, students are also not trained with literacy and reasoning questions. Biological literacy is very important in life, because biological elements cannot be separated from life, students who have biological literacy skills will become scientific informants both for themselves and their social environment. Biological literacy is able to encourage someone to think critically about the knowledge they have from literacy. Apart from biological literacy, something that is closely related to critical thinking skills is metacognitive abilities. One indicator of critical thinking is self-regulation, how a person is able to control himself, know and be aware of himself, this is closely related to a person's metacognitive abilities. Metacognition has an important role in regulating and controlling a person's cognitive processes in learning and thinking more effectively and efficiently. Metacognitive activities are very important because they can train students to think at a higher level and be able to plan, control and reflect on all thinking activities that have been carried out. The use of metacognitive processes during learning will help students to be able to obtain learning that lasts a long time in students' memory and understanding (Iskandar, 2014). Metacognition is related to the development of critical thinking and is an important aspect in improving cognitive abilities. Students also need metacognition to improve thinking and problemsolving abilities (Az-Zahra et al., 2021). Therefore, researchers want to see the relationship between biological literacy, metacognitive abilities and critical thinking in junior high school students.

Method

This research is a quantitative descriptive study with a correlational study using survey methods to get an idea of the relationship between biological literacy and metacognitive abilities and students' critical thinking skills. The variables in this research are two variables in this research including the independent variable (X) and one dependent variable (Y), where biological literacy skills (X1) and metacognitive abilities (X2) are the independent variables and critical thinking skills (Y) are the dependent variable. The research design used in this research is as Figure 1.

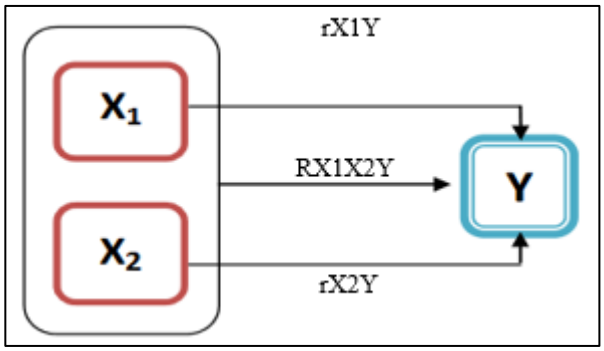

Figure 1. Research design

The research design explains that X1 (Biological Literacy), X2 (Metacognitive Ability) and Y (Critical Thinking Skills). while rX1Y (Relationship between biological literacy and critical thinking skills), rX2Y: Relationship between metacognitive ability and critical thinking skills and RX1X2Y (Relationship between biological literacy and metacognitive ability and critical thinking skills).

The research was carried out at Public Junior High School 3 Parungpanjang, Bogor district, and was carried out in September 2023 and June 2024 in the even semester of the 2023/2024 academic year. The population in this study were all middle school students in class VII of Public Junior High School 3 Parungpanjang, Bogor Regency, academic year 2023-2024. The samples were selected using the Slovin formula, randomly obtaining 150 samples from 240 selected respondents. Critical thinking skills are measured with a critical thinking instrument in the form of essay questions developed from 6 aspects of critical thinking (Facione, 2011). Biological literacy is measured with a biological literacy instrument in the form of multiple choice questions with 4 levels of biological literacy dimensions. Metacognitive ability is measured with a metacognitive ability instrument in the form of essay questions developed from 3 metacognitive aspects (Iskandar, 2016). The test questions used have been tested for content validity and construct validity and reliability. For each variable, an assessment rubric has been developed. The data analysis technique used is the regression correlation analysis technique with the help of the SPSS program. The test questions used have been tested for content validity and construct validity and reliability. For each variable, an assessment rubric has been developed. The data analysis technique used is the regression correlation analysis technique with the help of the SPSS program.

Results and Discussion

Based on the research results, the descriptive statistical data used consisted of minimum score, maximum score, average, score range, and standard deviation (standard deviation) for each variable as shown in Table 1.

Tabel 1. Summary of Research Descriptive Statistics

No	Indicator	Biological Literacy	Metacognitive Ability	Critical Thinking
1	Average Score	65.20	64.07	68.73
2	Minimal Scor	20	37	35
3	Maximal Scor	100	95	95
4	Standard Deviation	19.24	16.94	13.39
5	Range	80	58	60

Critical Thinking

Based on the results of research on critical thinking skills, it is known that the average student thinking skills are in the high category. This indicates that students are able to apply critical thinking in learning. The indicator of critical thinking skills that gives the highest score is analysis, namely 82.17 with a very high category, students have been trained to analyze problems and choose appropriate problem solving strategies. Meanwhile, the lowest indicator in the medium category is self-regulation with an average score of 54.83, indicating that students are still not able to optimally use their critical thinking skills to apply and implement them in their environment. Interpretation of the critical thinking skills score for each indicator can be seen in the Figure 2.

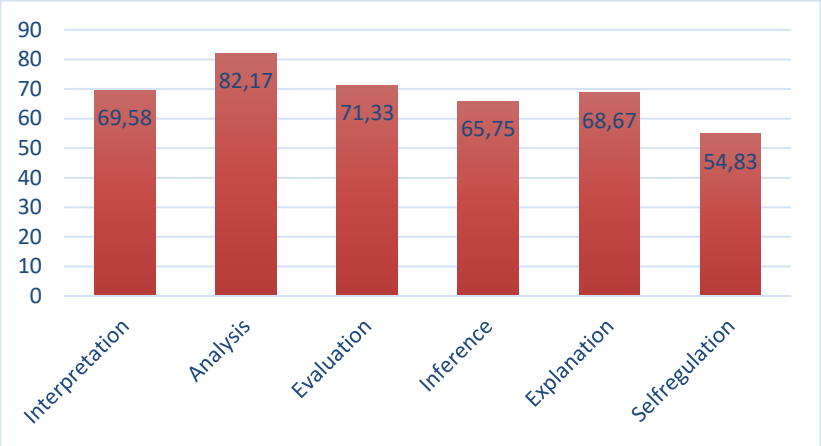

Figure 2. Student Critical Thinking Skills Score for each Indicator

The Figure 2 shows the scores of students' critical thinking skills per indicator sequentially from the highest to the lowest, starting from the indicators of analysis, evaluation, interpretation, explanation, inference and the lowest is self-regulation.

Biology Literacy

Based on the results of research on students' biological literacy which is classified as moderate, this shows that students are not fully able to develop their biological literacy skills. The biological literacy dimension that gives the highest score is the nominal dimension with an average score of 83.56 with good criteria, which shows students understand basic biological concepts, such as basic facts and terms. The indicator with the lowest average score in the very weak category is multidimensional with a score of 47.67, which means students are very weak in linking their biological knowledge with other sciences as well as with the environment and its benefits for many other aspects of life. Interpretation of the biological literacy score for each dimension can be seen in Figure 3.

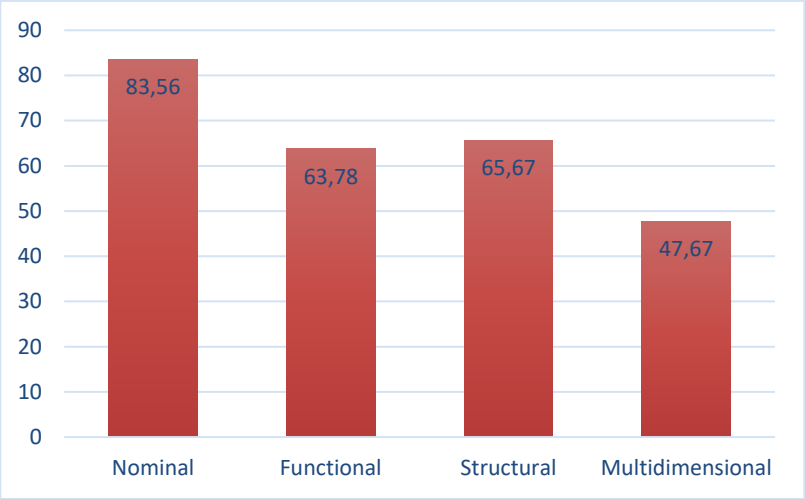

Figure 3. Student Biology Literacy Score for each Indicator

The Figure 3 shows students' biological literacy scores per biological literacy dimension, respectively, from highest to lowest, namely the nominal, structural, functional dimensions and the lowest, the multidimensional dimension.

Metacognitive Ability

Based on research on students' metacognitive abilities, students' metacognitive abilities are in the sufficient category. Students' metacognitive abilities are sufficient, indicating that students have sufficient ability to control their thinking. Students are quite capable of using their cognitive abilities in learning but still need to be developed and stimulated. The indicator of metacognitive ability that gives the highest score is planning with a score of 74.90 in the good category, where students have the ability to plan learning and design appropriate learning. Meanwhile, the indicator in the deficient category is a monitoring indicator with a score of 51.94 so it is in the deficient category. This is influenced by students' low ability to carry out self-assessment or assess the strategies they use in learning. Interpretation of the metacognitive ability scores for each indicator can be seen in Figure 4.

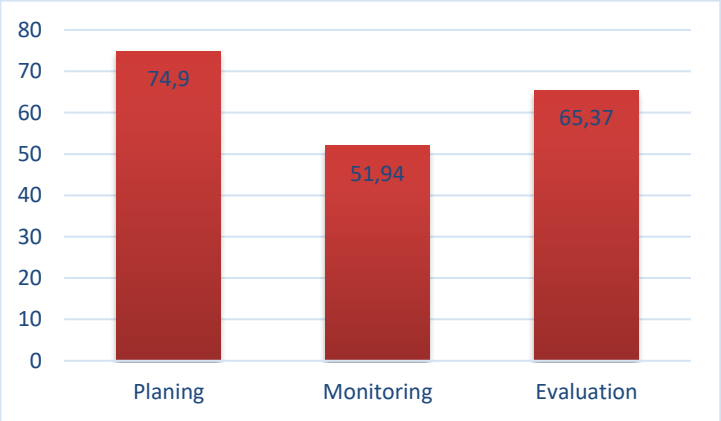

Figure 4. Student Metacognitive Ability Score for each Indicator

The Figure 4 shows the students' metacognitive ability scores per indicator in sequence from the highest to the lowest, namely the planning indicator, next is the assessment and the lowest is the monitoring indicator.

The relationship between biological literacy and critical thinking

Based on the results of normality tests carried out, critical thinking skills, biological literacy and metacognitive abilities have absolute values of 0.099, 0.066 and 0.176 respectively. So it can be seen that the data comes from a normally distributed population. A summary of the results of hypothesis testing can be seen in Table 2. The results of calculating the regression model between biological literacy and critical thinking obtained a = 52,301 and the regression coefficient b = 0.252, resulting in a simple

linear regression model Ŷ= 52,301 + 0.252X1. The equation obtained shows that if there is an additional 1 score in biological literacy, the critical thinking score will increase by 0.252 at a constant of 52.301. The significance test shows Sig of 0.000 less than 0.05 Table 3 and and the linearity test is 0.162 > 0.05. Table 4. This shows that there is a significant relationship between biological literacy and critical thinking.

Table 2. Calculation Results of Simple Linear Regression Model between Biological Literacy (X1) and Critical Thinking (Y)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	52.301	3.623		14.437	.000
	Biological Literacy	.252	.053	.362	4.723	.000

Table 3. Significance Test Results of Simple Linear Regression Model Between Biological Literacy (X1) and Critical Thinking (Y)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3502.727	1	3502.727	22.354	.000[b]
	Residual	23190.606	148	156.693		
	Total	26693.333	149			
a. Dependent Variable: Critical thinking						
b. Predictors: (Constant), Biological Literacy						

Table 4. Linearity Test Results of Simple Linear Regression Model Between Biological Literacy (X1) and Critical Thinking (Y)

			Sum of Squares	Df	Mean Square	F	Sig.
Critical thinking * Biological Literacy	Between Groups	(Combined)	5956.433	8	744.554	5.063	.000
		Linearity	3502.727	1	3502.727	23.817	.000
		Deviation from Linearity	1820.89	7	260.12	1.530	.162
	Within Groups		23969.06	141	169.99		
	Total		26693.33	149			

After testing the regression model, correlation coefficient analysis was carried out using the Pearson Product Moment formula with the results in Table 5.

Table 5. Calculation Results of the Correlation Coefficient Between Biological Literacy (X1) and Critical Thinking (Y)

		Biological Literacy	Critical thinking
Biological Literacy	Pearson Correlation	1	.362**
	Sig. (2-tailed)		.000
	N	150	150
Critical thinking	Pearson Correlation	.362**	1
	Sig. (2-tailed)	.000	
	N	150	150
*. Correlation is significant at the 0.05 level (2-tailed).			

Based on Table 5, it can be seen that the correlation coefficient (rxIy) is 0.362 with a significance of 0.000<0.05, so reject H0, which means there is a significant relationship between biological literacy and critical thinking. Based on this research, the results obtained show that the first hypothesis is a positive relationship between biological literacy and students' critical thinking, namely a significance value of <0.05, so reject H0 which means there is a relationship. This shows that biological literacy is related to and contributes to critical thinking. Critical thinking is an important skill that supports the development of strong biological literacy. The ability to question, analyze, evaluate, and synthesize information in a biological context not only helps students to better understand scientific concepts, but also prepares them to take an active role in a society that is increasingly involved with scientific and technological issues (William 2010). Biological literacy and critical thinking are interrelated and mutually reinforcing in the context of education and scientific understanding (Belecina & Ocampo, 2018). Good biological literacy not only includes an understanding of scientific facts and concepts, but also the ability to apply this knowledge by thinking critically. This provides a strong foundation for students to become

informational and scientific decision makers in a biological context (Juhji & Mansur, 2020). Good biological literacy not only improves understanding of the subject, but also develops critical thinking skills that are important in scientific contexts and everyday life. The ability to evaluate information, solve problems, and make informational decisions is a direct result of the combination of biological literacy and strong critical thinking (Hanim, 2019).

Relationship between Metacognitive Ability and Critical Thinking

The results of the regression model calculation obtained in calculations using SPSS 20 present a regression model between metacognitive ability and critical thinking, obtained a = 75,539 and the regression coefficient b = -0.106, resulting in a simple linear regression model $\hat{Y}$= 75,539 - 0.106 X2 (Table 6). The equation obtained shows that if there is an additional 1 score in metacognitive ability, the critical thinking score will decrease by 0.106 at a constant of 75.539. The significance test shows a result of 0.101>0.05 (Table 7) and a linearity test of 0.211>0.05 so that the regression model is declared linear and not significant (Table 8). After testing the regression model, correlation coefficient analysis was carried out using the Pearson Product Moment formula with the results in Table 9.

Table 6. Calculation Results of Simple Linear Regression Model between Metacognitive Ability (X2) and Critical Thinking (Y)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	75.539	4.259		17.738	.000
	Metacognitive Abilities	-.106	.064	-.135	-1.653	.101

Table 7. Significance Test Results of Simple Linear Regression Model between Metacognitive Ability (X2) and Critical Thinking (Y)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	483.685	1	483.685	2.731	.101[b]
	Residual	26209.649	148	177.092		
	Total	26693.333	149			
a. Dependent Variable: Critical Thinking						
b. Predictors: (Constant), Metacognitive Abilities						

Table 8. Linearity Test Results of Simple Linear Regression Model Between Metacognitive Ability (X2) and Critical Thinking (Y)

			Sum of Squares	Df	Mean Square	F	Sig.
Critical Thinking * Metacognitive Abilities	Between Groups	(Combined)	7131.249	33	216.098	1.281	.169
		Linearity	483.685	1	483.685	2.868	.093
		Deviation from Linearity	6647.564	32	207.736	1.232	.211
	Within Groups		19669.256	19562.084	116	168.639	
	Total		26693.333	26693.333	149		

Based on the results of the table above, calculating the correlation coefficient, it can be seen that the correlation coefficient (rxly) is 0.135 with a significance of 0.101>0.05, so accept H0, which means there is no significant relationship between metacognitive abilities and critical thinking. Based on the second hypothesis, it can be seen that there is no relationship between metacognitive abilities and critical thinking with a significant value <0.05, so accept H0 which means there is no relationship. The lack of correlation between metacognitive abilities and critical thinking can be caused by the self-regulation indicator in the critical thinking indicator which has a medium category which indicates that students are not yet able to control themselves, recognize their abilities and apply learning that is appropriate and appropriate to themselves. Self-regulation is the ability that students have to think, control themselves, direct feelings and behavior towards the learning environment and will evaluate and monitor their learning activities. Self-regulation will help students to learn in a disciplined manner and improve students' critical thinking skills and learning outcomes (Budiwiguna et al., 2022).

Table 9. Calculation Results of the Correlation Coefficient Between Metacognitive Ability (X2) and Critical Thinking (Y)

Correlations			
		Critical Thinking	Metacognitive Abilities
Critical Thinking	Pearson Correlation	1	-.135
	Sig. (2-tailed)		.101
	N	150	150
Metacognitive Abilities	Pearson Correlation	-.135	1
	Sig. (2-tailed)	.101	
	N	150	150

The absence of a relationship between metacognitive skills and critical thinking is influenced by several factors, one of which is the time of data collection. Data collection was carried out during the day in the last hour of learning so that respondents were less careful about the results of their answers and when one respondent had finished answering questions the other respondent would lose focus so that the results obtained were not significant. This is supported by the opinion which states that in general there are several factors that influence students' metacognitive abilities, namely internal factors including intelligence, motivation, habits, anxiety, interests, and so on and external factors including the family environment, school environment, community environment, socio-economic conditions, and so on (Ismarani & Putu Artayasa, 2023). Apart from that, students' boredom in answering questions, the form of the questions and their supervision while working on the questions also influence how these variables are related. Furthermore, the curriculum or teaching methods are inadequate or do not integrate the development of metacognitive and critical thinking skills in biology learning, so the relationship between metacognitive abilities and critical thinking may not be well formed. A curriculum that is too focused on mastering biological facts without considering the development of critical thinking and metacognitive skills can inhibit student involvement in deep thought processes (Garrison et al., 2001). Students can have different levels of metacognitive and critical thinking abilities. This can be caused by factors such as previous educational background, intelligence, or interest in certain subjects. This lack of uniformity can influence how strong or how clear the relationship between students' metacognitive and critical thinking abilities is in students' learning experiences.

Relationship between Biological Literacy and Metacognitive Ability and Critical Thinking

The multiple regression model is $\hat{Y}$= a + b1X1 + b2X2, where the regression model obtained is with a=62.196 and coefficient b1 = 0.308 and b_2= -0,212 so that the regression model $\hat{Y}$= 62.196+0.318 X1 -0.2127X2 is obtained (Table 10). Based on this equation, it can be seen that for every 1 increase in biological literacy score (X1), the critical thinking score (Y) increases by 0.318 and for every 1 increase in metacognitive ability score (X2), the critical thinking score (Y) will decrease by 0.212 at a constant of 62.196.

Based on the significance test of the multiple regression model, a significance value of 0.000 > 0.05 was obtained so that the regression model $\hat{Y}$= 62.196 +0.308 X1 -0.212X2 was declared significant Table 11. Based on the calculation of the multiple correlation coefficient, a significance value of 0.000<0.05 is obtained so that there is a correlation between biological literacy (X1) and metacognitive ability (X2) and critical thinking (Y). The calculation results are described in Table 12. Based on the table, it shows an R value of 0.444, which is meant by the correlation between the biological literacy variables and metacognitive ability simultaneously on metacognitive ability with medium correlation criteria.

Table 10. Calculation Results of Multiple Linear Regression Models between Biological Literacy (X1) and Metacognitive Ability (X2) and Critical Thinking (Y)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	62.196	4.515		13.775	.000
	Metacognitive Ability	-.212	.061	-.268	-3.462	.001
	Biological Literacy	.308	.054	.443	5.717	.000

Table 11. Significance Test Results of Multiple Linear Regression Models between Metacognitive Ability (X2) and Critical Thinking (Y)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5251.264	2	2625.632	18.000	.000[b]
	Residual	21442.069	147	145.864		
	Total	26693.333	149			
a. Dependent Variable: Critical Thinking						
b. Predictors: (Constant), Biological Literacy, Metacognitive Ability						

Table 12. Calculation Results of the Correlation Coefficient between Biological Literacy (X1) Metacognitive Ability (X2) and Critical Thinking (Y)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.444[a]	.197	.186	12.077	.197	18.000	2	147	.000
a. Predictors: (Constant), Biological Literacy, Metacognitive Ability									
b. Dependent Variable: Critical Thinking									

There is a mutual relationship between biological literacy, metacognitive abilities and critical thinking. This shows that critical thinking skills influence students' metacognitive and biological literacy scores with a significance value of <0.05 with a close correlation with a value of 0.444 if interpreted, this relationship is in the medium category, this is influenced by the calculation results which show the relationship between metacognitive and critical thinking in This research is not significant, so the simultaneous or joint relationship between biological literacy (X1) and metacognitive abilities (X2) with critical thinking (Y) has a low correlation value. Metacognitive abilities actually play a very important role in learning, metacognitive abilities are what lead students to the learning stage of critical thinking and literacy because metacognitive abilities contain students' awareness of how they learn. Metacognitive knowledge is able to make students aware of how they learn, monitor their learning progress, and regulate their cognitive activities (Azevedo, 2020). Students who are able to plan learning strategies and make learning adjustments according to their needs are students who have good metacognitive abilities. Meanwhile, critical thinking skills enable students to be actively involved in the learning process they have designed.

A series of structured metacognitive abilities will provide opportunities for students to be active in learning, thus forming students' critical thinking abilities. Critical thinking skills allow students to provide a more objective assessment of the information they encounter. This ability refers to students' ability to evaluate the extent to which a source of information is trustworthy or reliable. Students with high critical thinking skills can assess the credibility of information and its relevance and identify bias in it (William, 2010). Critical thinking skills enable students to make conclusions based on the evidence they find so that their decision making becomes more based. Students do not just receive information passively, but they actively analyze, evaluate, and interpret existing evidence. In addition, students can also evaluate the reliability and strength of the evidence, by considering data collection methods, information sources, or consistency with existing knowledge or concepts (Hanim, 2019).

The use of an independent curriculum in the biology learning process can help teachers and students learn broad biological concepts. In this way, students have the opportunity to study concepts in depth according to the development of their learning stages. This is actually an opportunity to improve students' biological literacy skills by involving students directly in designing, using and discovering as well as evaluating and applying the biological knowledge they have. Biological literacy is a skill that students have, how students can apply their knowledge in their daily environment, this requires a critical thinking process regarding facts or problems that exist in their daily environment. Biological literacy not only increases understanding of biological science, but also helps in developing critical thinking skills needed to make informed decisions and participate in complex scientific and public discussions (Firdaw et al, 2022). Biological literacy skills are considered capable of forming students' critical thinking abilities because there is stimulation to actively read and study biological phenomena to answer problems related to the phenomena being faced, resulting in an increase in cognitive abilities and critical thinking skills. Critical thinking skills and biological literacy are closely related, critical thinking skills are an important component in information literacy. Critical thinking skills and dispositions must guide each element of information literacy (finding, evaluating, and using information). Information literacy is a real skill, and critical thinking is a real abstract skill. Information literacy is content that requires students to think critically (Firdaw et al, 2022).

Conclusion

Based on the research results, it can be concluded that there is a positive relationship between biological literacy and students' critical thinking on biodiversity material. There is no relationship between metacognitive abilities and students' critical thinking on biodiversity material and there is a simultaneous relationship between biological literacy and metacognitive abilities and students' critical thinking on biodiversity material. Several indicators with low values affect the relationship that occurs between these variables, such as the relationship between critical thinking and metacognitive abilities, where metacognitive abilities cannot optimally explain critical thinking and the correlation value between research variables is not strong.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

N Najmah: methodology, analysis, writing – original draft preparation, review, and editing. **R. Rusdi**: writing-original draft preparation, evaluation, review, and editing. **R. H. Ristanto**: writing-original draft preparation, evaluation, review, and editing.

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