

# The Influence of Thinking Styles on Students' Critical Thinking in Biology Learning Using Research-Based e-LKPD

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## ARTICLE INFO

### Keywords:

critical thinking skills;  
influence;  
research-based e-LKPD;  
thinking styles

### Article history:

Received 2025-03-07

Revised 2025-06-17

Accepted 2025-09-30

## ABSTRACT

Thinking styles represent individuals' preferred ways of processing and solving problems, which may influence the development of higher-order thinking such as critical thinking. In the digital era, learning environments supported by technology, such as research-based electronic worksheets (e-LKPD), can accommodate diverse thinking styles and foster critical thinking. This study aimed to examine the influence of thinking styles on students' critical thinking skills in biology learning assisted by e-LKPD. A total of 112 high school students were selected through random sampling. Data were collected using the Yanpiaw Creative-Critical Thinking Styles (YCCTS) instrument and a standardized critical thinking skills test. Regression analysis was employed to measure the relationship between thinking styles and indicators of critical thinking, including interpreting, analyzing, applying, evaluating, and concluding. The regression results indicated a significant relationship between thinking styles and critical thinking skills ( $p < 0.05$ ). The  $R^2$  values demonstrated strong predictive power across all indicators: interpreting (82.4%), analyzing (85.7%), applying (81.6%), evaluating (85.5%), and concluding (79.9%). Students with dominant critical thinking styles showed higher scores in critical thinking tests compared to those with balanced or creative styles. These findings suggest that thinking styles can serve as predictors of students' critical thinking performance. Moreover, the use of research-based e-LKPD provides a supportive learning environment that enhances the expression of thinking styles, thereby strengthening critical thinking skills. Integrating digital, research-based learning resources is an effective strategy to align with students' thinking styles and promote critical thinking in science education.

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## 1. INTRODUCTION

Thinking style is a characteristic that a person has in the learning process to achieve learning goals, one of which is critical thinking skills (Ismail, Hasanuddin, & Chandra, 2023). Thinking style is defined

as the way chosen to use and express the abilities possessed (Hammad & Awed, 2023). Thinking style is not about the abilities a person has, but a person's preference in their cognitive process (remembers, understands) to solve problems in the way or expression they like (Agarwal & Rani, 2015), (John & Thomas, 2019). Thinking style refers to a person's preferred technique or method for using their abilities to acquire knowledge and organize their ideas. Furthermore, thinking style cannot be equated with thinking strategy, thinking style refers to a person's unique way of processing information in many situations stably. While thinking strategy is a mental process that is applied to certain conditions, sequentially, and tends to be slow in completing certain tasks (Ellala, Abu-Attiyeh, & Alghazo, 2020). Students who have difficulty using their thinking style tend to experience cognitive burden in solving a problem. Conversely, students who use their thinking style in an organized manner will be able to use their cognitive abilities in solving problems, so that they can improve their learning achievement (K Alenizi, 2020).

Students' thinking styles and critical thinking skills are important factors that need to be considered to create quality learning. Thinking style has a positive correlation with critical thinking skills which are said to be a reference in developing critical thinking skills through an effective learning environment (Asma, Ramat Ullah, & Bart, 2020). This is emphasised by the statement (Apaydin & Cenberci, 2018) in their research that in order to create quality education, a teacher needs to create an effective environment so that students can use their thinking styles as a form of the process of developing critical thinking skills.

A person's thinking style will be more easily expressed if accommodated through an effective learning environment. Therefore, it is important for educators (teachers) to provide a learning environment that is in line with the learning style needs of students. One approach or method that can be used to create such an environment is to provide teaching materials that can facilitate the needs of students in the digital era, such as research-based e-LKPD. E-LKPD which integrates research steps with the help of technology that is presented interactively and attractively can facilitate the use of students' logical thinking, reasoning, analyzing, predicting, and interpreting skills. This is relevant to statements (Arina, Munawaroh, Rosidi, & Hidayati, 2019), (Fitri April Yanti, Partono, 2017), (Daryanes & Sayuti, 2023), (Saptuti Susiani, Salimi, & Hidayah, 2018) that learning that applies a research approach can improve students' critical thinking skills. (Nuraini, Restuningdiah, Sidharta, & Utami, 2021) explained that research-based learning can facilitate 21st-century skills such as critical thinking skills, communication, creativity and collaboration. Furthermore, the results of research (Reyk, Leasa, Talakua, & Batlolona, 2022) have recommended the application of research-based learning in science learning. Learning that integrates technology in its application is very relevant to the needs of students in the digital era. This is supported by research findings of (Syahfitri, 2024), (Syahfitri & Muntahanah, 2023) that today's students are a digital native generation, 95.8% of whom stated that they need digital-based learning that can create an effective and enjoyable learning environment.

(Yazar Soyadı, 2015) his research revealed that one of the requirements for the use and development of critical thinking skills is that students must be able to approach problems through the environment. (Butterworth & Thwaites, n.d.) added that through problem solving students will learn to use their thinking skills. Students who are able to solve problems will be trained to make evaluative judgments about the information received, use logic, and systematics, make decisions and be independent. Furthermore, (Güngör & Akkaş Baysal, 2024) revealed that a person's skills in solving problems are also determined by the thinking style they have. According to (Cintamulya, 2019) the development of thinking styles and thinking skills can be done by designing meaningful learning that can provide opportunities for students to observe problems in the environment. (Indirwan Priyatno N, Kalsum, Muhammad Yunus Nurdin, 2024) revealed that identifying thinking styles can help teachers understand the mindset used by students, so that they can determine supporting factors for the development of students' thinking styles, such as the media and materials used.

The statements above confirm that thinking style and critical thinking skills have a close correlation and the development process is determined by the environment, especially effective learning design. Research findings (Leasa, 2018) stated that the development of critical thinking skills is not influenced by emotional intelligence factors but rather by thinking style and learning environment, thus recommending further identification of the influence of thinking style and environmental factors on critical thinking skills. In addition, (Mohsin, Naureen, & Rana, 2021), (Kamarulzaman, Oo, Mohd Jodi, Che Aziz, & Mahmood, 2021) in their research result also recommend further research on efforts to understand students' thinking styles and environmental needs according to the characteristics of each student to improve critical thinking skills. (Qummer & Zamir, 2020) added that thinking style is not categorised as good or bad, but it is important to know so that by being aware of it, someone can manage the thinking style they prefer.

Based on the literature review that has been explained previously, it can be interpreted that thinking style, critical thinking, and learning environment are important variables in learning and influence each other, but there has been no research that focuses on assessing the influence of these three variables, especially integrating a digital learning environment. Therefore, this study aims to assess the influence of thinking styles on students' critical thinking in biology learning using research-based e-LKPD. In detail, the research question is how does thinking style influence students' critical thinking in biology learning using research-based e-LKPD? The hypothesis in this study is as follows:

H0: There is no significant implication between thinking style and critical thinking skills

H1: There is a significant implication between students' thinking style and critical thinking skills

## 2. METHODS

This study is a quantitative study by applying simple regression to see the extent of the implications of thinking style on students' critical thinking skills in biology learning assisted by research-based e-LKPD. Critical thinking style is determined as variable X and critical thinking skills as variable Y.

The research population was students from high schools in Bengkulu Province, and a sample of 112 students were determined through random sampling techniques. Data collection was carried out in 3 stages, namely: 1) providing a thinking style instrument to students before learning begins. The thinking style instrument refers to the Yanpiaw Critical-Creative Thinking Styles (YCCTS). The YCCTS used has been checked for its validity and reliability values through the Product Moment test with a total score of 0.90 (critical thinking style = 0.81 and creative thinking style = 0.85). Meanwhile, the validity value for the critical thinking skills test is 0.84 and 0.87 for the reliability value, 2) implementing problem-based learning with the help of research-based e-LKPD, 3) providing a critical thinking skills test instrument to students after learning is complete.

The e-LKPD used is a digital worksheet that is specifically designed to follow the flow of a scientific study. Several components contained in the research-based e-LKPD are: 1) orientation that includes the presentation of case studies that will be observed and analyzed by students, 2) identifying problems, 3) submitting hypotheses, collecting data and proof, 4) interpretation and conclusions. This research was conducted during 5 meetings as detailed in Table 1.

**Table 1.** Summary of Three Stages of Research

| Research Stage                                                                 | Meeting | Summary of activities                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pretest Administration                                                         | 1       | Before applying the treatment, students' initial abilities were assessed through a pre-test. This stage applied the Yanpiaw Critical-Creative Thinking Styles (YCCTS) to determine students' critical thinking styles.                                                                |
| Implementation of research-based e-LKPD using the Problem Based Learning model | 2       | Students are asked to analyze a case or phenomenon that occurs around life through videos that are already available in e-LKPD. Students then identify the problems that occur. In addition, at this stage students are also asked to design problem solving that will be carried out |
|                                                                                | 3       | In this meeting, students collect data by conducting mini research through observations in the surrounding environment and experiments (according to the available options). The collected data is tabulated for analysis.                                                            |
|                                                                                | 4       | Students interpret the data obtained and draw conclusions. At this stage, students are given the opportunity to convey the findings they have obtained.                                                                                                                               |
| Posttest Administration                                                        | 5       | At this stage, students are given a posttest using a critical thinking skills test. The posttest results are used as a reference in interpreting whether there is an influence of the critical thinking style possessed by students with the critical thinking skills they have.      |

The data analysis technique applies a simple regression test with the help of SPSS Statistics 27. Students' critical thinking style score data is used as a benchmark for interpreting the level of critical thinking style skills they have. It was divided into 5 categories: superior creative thinking style, creative thinking style, balanced thinking style, critical thinking style, and superior critical thinking style. Determination of the level of critical thinking style follows the score range in Table 2.

**Table 2.** Thinking Style Score Interpretation Criteria (Chua, 2018)

| No | Score Range | Interpretation    |
|----|-------------|-------------------|
| 1  | 1.0 – 2.0   | Superior Creative |
| 2  | 2.0 – 4.5   | Creative          |
| 3  | 4.6 – 5.5   | Balance           |
| 4  | 5.6 – 8.0   | Critical          |
| 5  | 8.1 – 9.0   | Superior Critical |

Critical thinking skills used are guided by indicators and sub-indicators of critical thinking according to Facione & Angelo, which have been modified, namely interpreting, analyzing, applying, evaluating, and concluding (Seventika, Sukestiyarno, & Mariani, 2018). Meanwhile, the critical thinking skills scores are analyzed and interpreted referring to the critical thinking category (Riduwan, 2013).

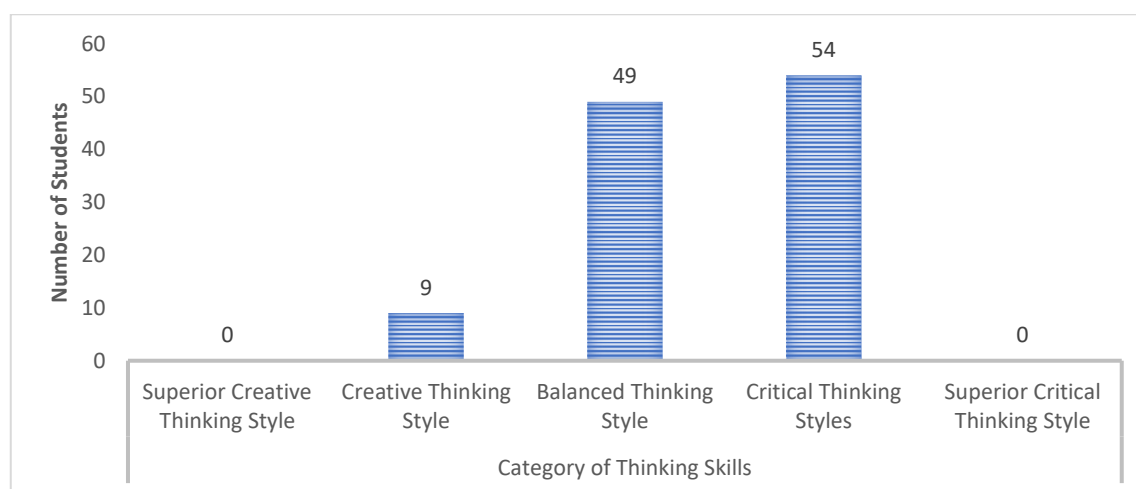
### 3. FINDINGS AND DISCUSSION

The findings of the study indicate that they have a dominant thinking style in the critical thinking style theory category. This is described in Table 3.

**Table 3.** General Description of Student Thinking Style Categories

| N   | Min  | Max  | Mean   | Std. Deviation | Interpretation          |
|-----|------|------|--------|----------------|-------------------------|
| 112 | 3.00 | 7.44 | 5.4846 | .79229         | Critical Thinking Style |

In detail, the critical thinking styles of students found are described into three categories of thinking styles, namely creative thinking styles, balanced thinking styles and critical thinking styles (Picture 1).



**Figure 1.** Students Thinking Styles in Biology Learning

Based on Figure 1, it can be observed that none of the students exhibited both superior creative thinking styles and superior critical thinking styles. Instead, students' critical thinking styles predominantly fall within the balanced and critical categories, suggesting a tendency toward analytical and evaluative approaches rather than imaginative or divergent ones. Figure 1 also illustrates that students' creative thinking styles were not prominently demonstrated during biology lessons, indicating a possible disconnect between the nature of the subject and the expression of creative cognition.

This finding is particularly relevant when considering the design and implementation of instructional strategies in science education. To further explore this, the thinking styles possessed by students were analyzed for their implications on the development of critical thinking skills following instruction using a research-based electronic student worksheet (e-LKPD). The analysis aims to investigate the extent to which individual thinking styles influence or contribute to students' abilities in interpreting, analyzing, applying, evaluating, and drawing conclusions from biological problems. By understanding these relationships, educators can better tailor learning materials and methods to support the cultivation of both critical and creative thinking skills in a more integrated manner.

**Table 4.** Thinking Styles and Their Implications for Critical Thinking Indicators

| Thinking Style                       | Indicators of Critical Thinking Skills |           |          |            |            | Averages |
|--------------------------------------|----------------------------------------|-----------|----------|------------|------------|----------|
|                                      | Interpreting                           | Analysing | Applying | Evaluating | Concluding |          |
| Critical                             | 84.07                                  | 83.28     | 83.02    | 82.81      | 83.50      | 83.30    |
| Balance                              | 76.35                                  | 75.22     | 75.16    | 73.76      | 74.51      | 75.00    |
| Creative                             | 63.33                                  | 64.56     | 64.11    | 64.11      | 63.33      | 63.90    |
| Averages of Indicators               | 74.58                                  | 74.35     | 74.10    | 73.56      | 73.78      |          |
| Averages of Critical Thinking Skills | 74.10                                  |           |          |            |            |          |

Table 4 explains that 54 students who have a critical thinking style have skills in interpreting, analyzing, applying, evaluating, and concluding with an average of 83.30. Furthermore, students who have a balanced critical thinking style category (49 students) have an average critical thinking skill of 75.00, while the average critical thinking skill of students in the creative thinking style category (9 students) is only 63.90.

**Table 5.** Anova of Regression Test

| Model                                                         |            | Sum of Squares | df  | Mean Square | F       | Sig.  |
|---------------------------------------------------------------|------------|----------------|-----|-------------|---------|-------|
| CT- Interpreting a                                            | Regression | 4718.689       | 1   | 4718.689    | 513.799 |       |
|                                                               | Residual   | 1010.231       | 110 | 9.184       |         |       |
|                                                               | Total      | 5728.920       | 111 |             |         |       |
| CT- Analysing a                                               | Regression | 4899.357       | 1   | 4899.357    | 659.125 |       |
|                                                               | Residual   | 817.643        | 110 | 7.433       |         |       |
|                                                               | Total      | 5717.000       | 111 |             |         |       |
| CT- Applying a                                                | Regression | 4721.675       | 1   | 4721.675    | 486.822 |       |
|                                                               | Residual   | 1066.887       | 110 | 9.699       |         | .000b |
|                                                               | Total      | 5788.563       | 111 |             |         |       |
| CT- Evaluating a                                              | Regression | 5345.608       | 1   | 5345.608    | 646.306 |       |
|                                                               | Residual   | 909.812        | 110 | 8.271       |         |       |
|                                                               | Total      | 6255.420       | 111 |             |         |       |
| CT- Concluding a                                              | Regression | 5265.484       | 1   | 5265.484    | 436.741 |       |
|                                                               | Residual   | 1326.194       | 110 | 12.056      |         |       |
|                                                               | Total      | 6591.679       | 111 |             |         |       |
| a. Dependent Variable: Indicators of Critical Thinking Skills |            |                |     |             |         |       |
| b. Predictors: (Constant), Thinking Style                     |            |                |     |             |         |       |

Table 5 describes the results of a simple regression test, explaining that the thinking style variable has a relationship or implication with increasing critical thinking skills. In other words, these results confirm that the predictor variable can be used to predict students' critical thinking skills for each indicator. This is indicated by a significance value of 0.000, less than 0.05. Furthermore, to see how strong the relationship is between the predictor variable and the predictant, it can be seen in Table 6.

**Table 6.** Model Summary of Regression Test

| Model | R     | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------|----------|-------------------|----------------------------|
| 1     | .908a | .824     | .822              | 3.03050                    |
| 2     | .926a | .857     | .856              | 2.72637                    |
| 3     | .903a | .816     | .814              | 3.11432                    |
| 4     | .924a | .855     | .853              | 2.87594                    |
| 5     | .894a | .799     | .797              | 3.47222                    |

Predictors: (Constant), Score of Thinking Style  
Dependent Variable: Score of Critical Thinking Skills/Indicators (1-5 Model)

Table 6 describes how strong the implications of thinking style are on changes in students' critical thinking skills, where the influence of the independent variable (thinking style) on improving critical thinking skills in each indicator is an average of 80 percent (thinking style - Interpreting = 82.4%, thinking style - analyzing = 85.7%, thinking style - applying = 81.6%, thinking style - evaluating = 85.5%, and thinking style - concluding = 79.9%). These results confirm that thinking style has a strong influence on improving students' critical thinking skills in biology learning.

**Table 7.** Coefisient Correlation of Regression Test

| Model            |                | Unstandardized Coefficients |            | Standardized Coefficients |  | T      | Sig. |
|------------------|----------------|-----------------------------|------------|---------------------------|--|--------|------|
|                  |                | B                           | Std. Error | Beta                      |  |        |      |
| CT- Interpreting | (Constant)     | 33.892                      | 2.012      |                           |  | 16.847 |      |
|                  | Thinking Style | 8.229                       | .363       | .908                      |  | 22.667 |      |
| CT- Analysing    | (Constant)     | 32.259                      | 1.810      |                           |  | 17.824 |      |
|                  | Thinking Style | 8.385                       | .327       | .926                      |  | 25.673 |      |
| CT- Applying     | (Constant)     | 32.913                      | 2.067      |                           |  | 15.920 |      |
|                  | Thinking Style | 8.232                       | .373       | .903                      |  | 22.064 | .000 |
| CT- Evaluating   | (Constant)     | 29.308                      | 1.909      |                           |  | 15.352 |      |
|                  | Thinking Style | 8.759                       | .345       | .924                      |  | 25.423 |      |
| CT- Concluding   | (Constant)     | 30.268                      | 2.305      |                           |  | 13.132 |      |
|                  | Thinking Style | 8.693                       | .416       | .894                      |  | 20.898 |      |

Dependent Variable: Score of Critical Thinking Skills

Furthermore, the correlation coefficient in Table 7 indicates that if students' thinking styles change, the increase in students' critical thinking skills can be estimated to be more than 8. In order, the estimated increase for each indicator of critical thinking skills is interpreting = 8.229, analyzing = 8.385, applying = 8.232, evaluating = 8.759, and concluding = 8.693.

The research findings explain that there are implications of the thinking style used by students on critical thinking skills in biology learning assisted by research-based e-LKPD. This is in line with the

research results of (Abdi, 2012), (Alimirzaloo & Hashemnezhad, 2015), (Shirazi & Heidari, 2019), (Sajedi, 2018) that there is a significant relationship between the learning environment, thinking style and students' critical thinking skills. (Yaakobi, 2017), (Romadhani & Lukmana, 2018), (Saprudin, Liliyasi, Prihatmanto, & Setiawan, 2019) added that thinking style can predict a person's quality in using their abilities to create new ideas, analyze, and be innovative (Saini, Shabnam, Seema, & Bhatnagar, 2022). Their findings explained that a person's skills in using metacognition will strengthen their thinking style.

The results also show that students' thinking styles with critical categories are better at providing implications for improving students' critical thinking skills in biology learning than thinking styles with balanced and creative categories (Table 4). This is likely because it is in line with inquiry-based learning supported by the existence of research-based e-LKPD. Through research-based learning, students are encouraged to be actively involved in searching for and analyzing data, evaluating, and making conclusions, thus supporting the improvement of students' critical thinking skills. This is in line with the findings of research conducted by (Mahardini, Khaerunisa, Wijayanti, & Salimi, 2019) that research-based learning can improve students' critical thinking skills because the process uses a problem-solving, cooperative and inquiry approach. Furthermore, (Wale & Bishaw, 2020) added that the application of learning with a research and inquiry approach can improve students' abilities in analyzing, interpreting, and evaluating which are important parts of critical thinking skills.

The thinking style possessed by students can help students in considering what approach they will use to obtain information. Students have the capacity to regulate and organize their thinking style according to instruction. In line with Aljojo's statement (Aljojo, 2017), thinking style will determine how a person responds and acts to an event.

Based on the researcher's observations, the use of research-based electronic student worksheets (e-LKPD) has proven effective in engaging students directly with real-world environmental problems. This approach not only encourages active learning but also indirectly facilitates the expression and development of students' preferred thinking styles, which are increasingly aligned with the cognitive characteristics of learners in the digital age. According to Aldossari and Moh'd Ali Abu Jadou (2021), the design of learning activities plays a critical role in addressing students' interests and accommodating their diverse thinking styles. Similarly, Ortega and Chua (2024) emphasize that engaging media, relevant materials, and well-structured instructional content significantly enhance students' motivation to utilize their cognitive preferences during learning.

Moreover, these findings reinforce the notion that there is a strong interrelationship between the learning environment, students' thinking styles, and their critical thinking skills. Tarigan (2017) notes that students who engage directly in problem-solving tasks—particularly through investigative or research-based activities—demonstrate improved critical thinking and problem-solving abilities. In line with this, Kuo (2016) argues that technology-integrated learning environments, such as those employing electronic-based instructional media, provide students with greater autonomy to express and apply their individual thinking styles in solving complex problems. Supporting this perspective, Hayati and Ali Noer (2021) as well as Sarkingobir, Egbebi, and Awofala (2023), contend that thinking styles are not only influenced by innate preferences but can also be shaped and enhanced through environmental exposure and experiential learning. Furthermore, Asma et al. (2020) and Lin et al. (2024) assert that thinking styles should be considered a foundational element in designing effective learning environments, particularly those aimed at fostering higher-order thinking skills.

The results of this research have the potential to provide beneficial contributions to the world of education. Furthermore, the practical implications of this research are that teachers can start to design and determine various learning innovations that can encourage the development of students' thinking styles and critical thinking skills. Determining students' thinking styles can help teachers understand

differentiation in the classroom so that the learning approach used can be carried out appropriately according to students' needs. However, researchers realise that this study still has several limitations, including the fact that it has not comprehensively examined other factors that may influence it, such as gender and age. Following the statement of (Çali, Lazimi, & Ippoliti, 2024), the need to observe several factors comprehensively can help avoid inaccurate data that arises.

#### 4. CONCLUSION

The research results explain that thinking styles have a strong relationship and influence or implications on the development of students' critical thinking skills. The thinking styles used by students in the learning process can be used as a guideline for determining students' critical thinking skills in time ahead. The findings of this research also have an important impact on the world of education, especially for teachers, where teachers have the responsibility to design learning processes that can facilitate thinking styles and the development of critical thinking skills. Furthermore, theoretically, this study also confirms the theory of cognitive styles in modern classes. The findings also recommend that teachers should prepare learning according to the thinking styles that students prefer so that the use of thinking styles and critical thinking skills can be carried out optimally. In addition, this finding confirms that teachers must assess students' thinking styles as a basis for considering the selection of appropriate teaching strategies or approaches. This study has several limitations, including that it is still carried out in general and has not measured other factors such as gender, age, and student study level. Therefore, future research is recommended to explore the correlation of thinking styles with other variables, such as motivation and digital literacy, by controlling for gender and study level.

**Acknowledgements:** The researcher would like to thank the Research and Community Service Institute of Muhammadiyah University of Bengkulu for providing support for the implementation of this study.

**Conflicts of Interest:** The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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