

Analysis of high school students' critical thinking ability in Bantul Regency on endocrine system material

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Abstract: Critical thinking is an essential ability for students in the 21st century, particularly in complex subjects like the endocrine system in biology, which requires a deeper conceptual understanding. This study aims to analyze the critical thinking ability profile of Grade XI high school students in Bantul Regency on the topic of the endocrine system, a subject often considered difficult due to its abstract nature. This research is a descriptive quantitative study using a purposive sampling technique, involving 260 Grade XI students from various high schools in Bantul Regency. The test used consists of 8 essay questions, designed based on Ennis' critical thinking aspects. The results reveal that the overall critical thinking ability of these students is still very low. Specifically, the percentage results for each aspect are as follows: the elementary clarification aspect is 37.8% with a very low category, the basic support aspect is 47.4% with a low category, the inference aspect is 25.5% with a very low category, the advance clarification aspect is 54.2% with a low category, and the strategy and tactics aspect is 47.8% with a very low category. These results provide a broader understanding of the critical thinking ability of Grade XI high school students in Bantul Regency, which can serve as a basis for educators in developing and designing various learning innovations aimed at enhancing pupils' capacity for critical thought.

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Introduction

Critical thinking is an essential skill and a significant goal in the field of education that students must possess in the current era of globalization (Fitriani *et al.*, 2022; Permana *et al.*, 2019; Trilling & Fadel, 2009). The Partnership for 21st Century Ability identifies critical thinking as one of the four main abilities necessary for shaping the younger generation to be ready to face the demands and challenges of the future (Erdem *et al.*, 2019; Roudlo, 2020). Critical thinking emphasizes reasoning and being reflective when deciding what to think or do (Ennis, 1985). This ability relates to how an individual approaches a problem, question, or issue to prove, interpret, and solve problems (Facione, 2015). According to Ennis (1985), critical thinking abilities are classified into five aspects; (1) providing simple explanations (elementary clarification), which includes focusing on questions, analyzing arguments, asking, and answering questions; (2) building basic ability (basic support), which includes considering the credibility of sources and making observational judgments; (3) drawing conclusions (inference), which includes formulating and considering deductions, formulating and considering inductions, making decisions, and evaluating the results; (4) providing further explanation (advanced clarification), which includes identifying terms and considering definitions, and identifying assumptions; (5) setting strategies and tactics (strategy and tactics), which includes determining actions and interacting with others. Amid the vast flow of information easily accessible through various digital technologies, developing critical thinking ability has become essential, especially for high school students who are in their teenage years. Developing critical thinking ability at this stage can help maximize their potential (Septiany *et al.*, 2024). Students who possess critical thinking ability will benefit in numerous ways, including assessing the accuracy of presented information, identifying sources and formulating solutions to problems, avoiding illogical thinking and reasoning errors, and scrutinizing various opinions, thereby enabling them

to evaluate and make decisions based on scientific truth (Chiras, 1992; Zubaidah, 2018; Zubaidah et al., 2015).

Critical thinking abilities are vital for engaging students in higher-order thinking and equipping them to critically examine various issues they encounter in everyday life. These abilities are also necessary to prepare students to compete in the workforce and become professionals in their fields (Gunawan et al., 2020; Mahanal et al., 2019; Saputri et al., 2018). Suarniati et al. (2018) further emphasize the necessity of fostering critical thinking by highlighting key reasons, such as (1) teaching students to appreciate others as a form of formal education; (2) preparing students to grow and understand themselves through independence and self-direction; (3) critical thinking is an educational goal reflected in various subjects, including science; and (4) critical thinking accommodates accurate analysis, sound reasoning, and deliberation, which are important in a democratic society. Although this ability is important, the level of critical thinking among students in Indonesia is relative low (Anisa et al., 2021; Hillary et al., 2023). This result aligns with literature review revealing that 57% of high school students have underdeveloped critical thinking abilities (Pujiastuti, 2023). Similar experiences were also reported in Azrai et al. (2020), which reveals that 59% of high school students possess minimal critical thinking abilities. The students' low critical thinking abilities are attributed to a teacher-centered learning approach and the reliance on rote memorization techniques, resulting in a significant lack of optimization in students' critical thinking abilities (Abda'u et al., 2023).

From interviews and observations conducted with various high school teachers in Bantul Regency, it is clear that students' critical thinking skills require enhancement. Many students struggle to interpret images and graphs, which are essential components of studying biology (Wahdah et al., 2023). The questions used in class are also still limited to those found in textbooks, making it difficult for students to answer questions that require critical thinking abilities, as they are not yet accustomed to such question types (Fauzi & Sa'diyah, 2019; Gustianingrum et al., 2023). This is reinforced by Sidabutar & Mercuriani, (2024), who note that students often find it challenging to analyze problems and are hesitant to express their opinions or draw conclusions during biology lessons. This issue has been exacerbated by the impact of the COVID-19 pandemic, which led to a decline in critical thinking abilities due to distance learning, limiting interactions (Hasnawati & Widodo, 2023). This suggests that critical thinking abilities must be developed and honed through educational procedures rather than being inborn (Rahmawati et al., 2016).

The endocrine system, a significant topic in biology, encompasses the study of hormones and glands that regulate various bodily functions, necessitating a deeper understanding. This topic includes abstract and complex concepts, as well as biological events that are not visible to the naked eye (Çimer, 2012; Tekkaya et al., 2001). This is in line with recent research conducted by Maryanti et al. (2024), which shows that the endocrine system ranks second in the category of subjects considered abstract and quite complicated to learn. These characteristics make it one of the most challenging subjects to study in biology (Çimer, 2012; Hadiprayitno et al., 2019). The complexity of this material provides an opportunity for developing students' critical thinking abilities. One way to do this is by relating problems in the endocrine system to everyday life (Fitarahmawati & Suhartini, 2021; D. Rahmawati, 2018; Vekli & Çimer, 2017). Although many previous studies have established the importance of critical thinking across various subjects, there is a significant gap in the literature discussing how the complex concepts of the endocrine system, which are still rarely used in teaching, can be effectively utilized to enhance students' critical thinking abilities.

This research offers a novel approach by utilizing the complexity of the endocrine system to train critical thinking, an area that has not been thoroughly explored in current educational research. Conducted in Bantul Regency, this study provides new insights into the critical thinking abilities of high school students in this specific region, which has not been widely studied. Given the significance of critical thinking ability in the modern world, this analysis is also needed to understand students' abilities in each aspect of critical thinking, allowing educators to identify which aspects need improvement (Novitasari, 2023). The findings from this research are anticipated to provide a comprehensive view of students' critical thinking capabilities on the topic and serve as a guide for teachers, aiding them in developing innovative teaching strategies that strengthen students' critical thinking abilities. Furthermore, the findings of this study will contribute to the body of effective pedagogical practices in biology education, ultimately preparing students for future challenges in both academia and the workforce.

Method

Research Sample

A descriptive quantitative technique was used in this study to provide a general picture of the critical thinking profile of Bantul Regency pupils. Purposive sampling was the method of sampling used in this investigation. This research involved students from 9 schools in Bantul Regency, totaling 260 students. Table 1 displays the sample data that were used in this investigation.

Table 1. Distribution of Research Sample

No.	Name of School	Number of Students
1.	SMAN 2 Banguntapan	34
2.	SMAN 3 Bantul	32
3.	SMAN 1 Dlingo	21
4.	SMAN 1 Imogiri	27
5.	SMAN 1 Jetis	36
6.	SMAN 1 Pajangan	19
7.	SMAN 1 Piyungan	35
8.	SMAN 1 Sewon	33
9.	SMAN 1 Srandakan	23
Total		260

Instrument Validation and Reliability

The data collection technique employed in this research involved 8 essay questions, which were developed based on the critical thinking ability indicators put forward by [Ennis \(1985\)](#), which include basic clarification, foundational support, inference, advanced clarification, as well as strategies and tactics. Before being utilized, the questions underwent a validation process.

The validation process began with an assessment by expert who evaluated the aspects of substance, construction, and language of the instrument. The results of the validation were analyzed using the criteria established by [\(Direktorat Pembinaan SMA, 2010\)](#). Subsequently, the questions were empirically tested by comparing the r-count to the r-table values to determine the validation of each question. Afterward, the reliability of the instrument was evaluated using Cronbach's Alpha to ensure the consistency of the results, following the reliability criteria established by [\(Rahman et al. 2023\)](#). The criteria for expert validation and test reliability are outlined in [Table 2](#) and [Table 3](#).

Table 2. Expert Validation Score Interpretation and Criteria

Score Range	Criteria
$Mi + 1.5 SDi \leq \bar{M} \leq Mi + 3,0 SDi$	Very good
$Mi + 0 SDi \leq \bar{M} < Mi + 1,5 SDi$	Good
$Mi - 1.5 SDi \leq \bar{M} < Mi + 0 SDi$	Less
$Mi - 3 SDi \leq \bar{M} < Mi - 1,5 SDi$	Very Less

Table 3. Reliability Test Criteria

Score	Category
$0.80 \leq r_{11} \leq 1.00$	Very high
$0.60 \leq r_{11} \leq 0.80$	High
$0.40 \leq r_{11} \leq 0.60$	Moderate
$0.20 \leq r_{11} \leq 0.40$	Low
$0.00 \leq r_{11} \leq 0.20$	Very Low

Data Analysis

The scoring of each question was adjusted according to the criteria in the critical thinking ability assessment rubric, with a score range of 0-3. The following [Formula 1](#) was used to examine the pupils' scores.

$$Score = \frac{Score\ obtained}{Maximum\ score} \times 100 \quad (1)$$

To ascertain the degree of students' critical thinking proficiency based on every aspect, the results will be translated into many categories. [Table 4](#) displays the requirements for critical thinking abilities as stated by [\(Ramdani et al. 2020\)](#).

Table 4. Categories of Critical Thinking Ability

Scale of Achievement	Criteria
$81.25 < x \leq 100$	Very High
$71.50 < x \leq 81.25$	High
$62.50 < x \leq 71.50$	Moderate
$43.75 < x \leq 62.50$	Low
$0 < x \leq 43.75$	Very Low

Results and Discussion

Results of Validity and Reliability Testing

The validation process for the 8 essay questions was carried out through expert judgment and empirical testing. Table 5 presents the results of the expert validation, which evaluated the instrument across three aspects: substance, construction, and language. Based on the scores obtained, all aspects were categorized as very good, indicating that the questions are appropriate.

Table 5. Results of expert validation

Items	Aspect	Maximum Score	Score obtained	Category
1	Substance	12	11	Very good
2	Construction	16	16	Very good
3	Language	12	11	Very good

Table 6, shows the results of the validity test for each question item, using the *r*-count and *r*-table comparison. All items demonstrated *r*-count values greater than the *r*-table value, indicating that each question is valid. This means the questions are able to measure what they are intended to measure with a high degree of accuracy.

Furthermore, the reliability test using Cronbach's alpha yielded a value of 0.748, as shown in Table 7. This falls into high category, which confirms that the instruments is reliable and can consistently assess students' critical thinking abilities. With this high level of reliability, the instruments can be trusted for use in further data collection and analysis. The instrument is shown to be both extremely reliable and valid by both the validity and reliability test, making it appropriate for evaluating critical thinking abilities within the framework of this study.

Table 6. Results of the question item validity test

Items	<i>r</i> count	<i>r</i> table	Category
1	0.646	0.138	Valid
2	0.565	0.138	Valid
3	0.653	0.138	Valid
4	0.550	0.138	Valid
5	0.572	0.138	Valid
6	0.589	0.138	Valid
7	0.654	0.138	Valid
8	0.624	0.138	Valid

Table 7. Results of reliability test

Cronbach Alpha	N of Items	Category
0.748	8	High

Students' Critical Thinking Ability

This study aims to analyze high school biology students' critical thinking abilities when studying the endocrine system. Table 8, displays the statistics on the frequency distribution percentage of students' critical thinking abilities.

Table 8. Frequency Distribution Percentage of Students' Critical Thinking Ability

Students' Critical Thinking Criteria	Number of Students	Frequency Percentage
Very High	1	0.38
High	7	2.69
Moderate	64	24.62
Low	49	18.85
Very Low	139	53.46
Total	260	100

Table 8, displays that among the 260 students who completed the test, 1 student achieved a very high level of critical thinking ability with a frequency percentage of 0.38%, 7 students achieved a high level of critical thinking ability with a frequency percentage of 2.69%, 64 students achieved a moderate level of critical thinking ability with a frequency percentage of 24.62%, 49 students achieved a low level of critical thinking ability with a frequency percentage of 18.85%, and 139 students achieved a very low level of critical thinking ability with a frequency percentage of 53.46%. Based on the results of Table 8 and Table

9 offers a more comprehensive analysis of each student's critical thinking capacity based on the five aspects of critical thinking.

Table 9. Percentage of Critical Thinking Ability Indicators

Aspect	Result Per Aspect (%)	Category
Elementary clarification	37.8	Very Low
Basic support	47.4	Low
Inference	25.5	Very Low
Advanced clarification	54.2	Low
Strategy and tactics	47.8	Low

A graph is shown in Figure 1 to more clearly show the variations in percentages across each aspect of critical thinking ability.

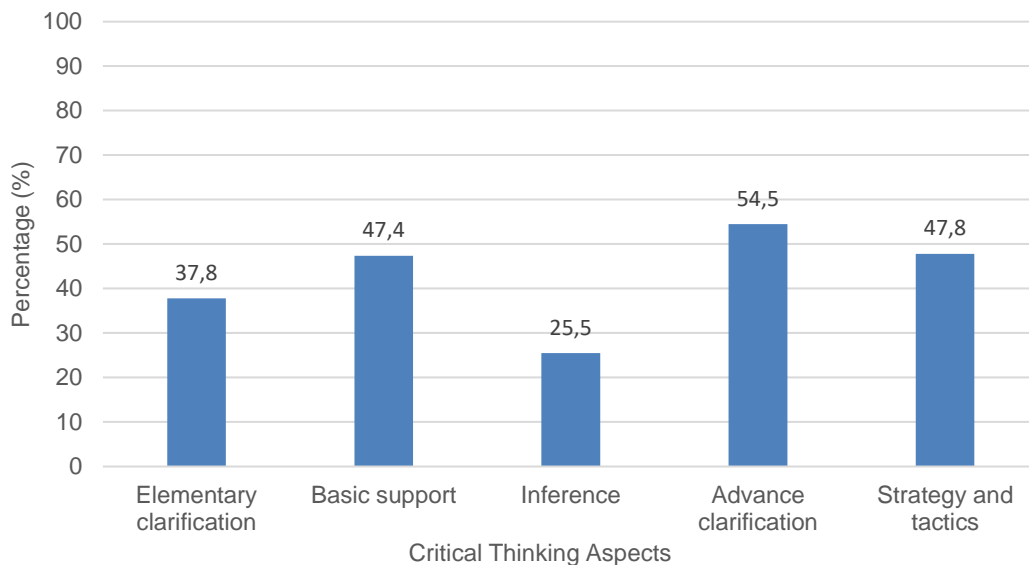


Figure 1. Results of Critical Thinking Ability Per Aspect

Considering the outcomes shown in Figure 1, it is shown that students' critical thinking ability in the aspect of elementary clarification is in the very low category with a percentage of 37.8%. The questions given in this aspect consist of two indicators: focusing on the question and analyzing arguments. In this aspect, students are considered unable to understand the question and analyze the argument of the question by providing appropriate answers supported by relevant sources. This is because students are less careful in understanding the meaning of the question. The answers provided by students tend to focus on common opinions they often hear without examining them in depth from various literature. This aspect still needs to be improved because it helps students become more critical in investigating and analyzing a problems, enabling them to understand the factors and issues involved well (Kumala et al., 2022).

To address this issue, it is crucial to enhance students' understanding of questions by involvement in group discussions. This is consistent with the research done by Fikrina et al. (2021), which indicate that group discussions can aid students in better comprehending questions, including testing their understanding through case examples. Furthermore, students can be trained to focus on analyzing arguments from diverse sources while encouraging them to independently seek information from literature. This approach will help students recognize various opinions and evaluate the truth of these opinions rationally and critically (Felton et al., 2015).

The second aspect, basic support, has an average percentage of 47.4% and falls into the low category. Basic support relates to the ability to assess the credibility of a source. In this aspect, students are considered unable to distinguish between reliable and unreliable sources of information and lack sufficient ability in verifying the validity of sources used to answer questions. The low performance in this aspect indicates that students still require guidance to train their ability to absorb various received information. This supports the findings of Septiany et al. (2024), which show that students with low abilities in assessing the credibility of a source need more direction to provide appropriate reasons based on the problems presented in the questions. As we know, the internet plays a significant role in helping

students understand material. However, the credibility of the sources used is crucial to ensure that the information obtained is reliable. Improvements in this aspect can be made by providing exercises that focus on verifying information from different sources. For instance, students can be tasked with finding the same information from various sources and then comparing their reliabilities and accuracy. Additionally, teachers should introduce a variety of information sources, both reliable and unreliable, and assign tasks that require students to assess their credibility (Topal & Shargh, 2023).

The third aspect, inference, falls into the very low category with an average percentage of 25.5%. In this aspect, students are asked to draw and consider conclusions from the problems presented in the images. The last step in the critical thinking process is drawing conclusions, as it refers to the overall information obtained that is used to draw conclusions. The test results show that students are not sufficiently critical in making well-founded conclusions about the presented problems. Students still struggle to draw conclusions from the provided graph and images. This is due to a lack of understanding and the inability to connect various pieces of information obtained (Raslan, 2023). To improve skills in this aspect, teachers can provide more exercise focused on the interpretation and analysis of data, such as graphs and images relevant to the lesson material. Understanding graphs and images in biology is crucial, as almost every problem can be visualized through them (Herpiandi et al., 2003). Graphs and pictures are useful tools for teaching and learning, particularly for science concepts, including biology (Roslina et al., 2020). Images can correct misconceptions because they convey more concrete and meaningful information than words, but this can only be achieved through practice (Umam, 2018). Furthermore, Herpiandi et al. (2003) emphasize the importance of understanding graphs, which can assist students in organizing, presenting, finding relationships, and evaluating datasets. With directed practice, students will become more skilled in linking various visual elements to draw more accurate conclusions.

The fourth aspect, advanced clarification, has an average percentage of 54.2%, placing it in the low category. This aspect achieved the highest score compared to the other aspects. Nevertheless, the achievement category is still low, indicating the need for improvement. In this aspect, students are considered unable to adequately consider definitions and predict issues related to the presented problem. Students often express their opinions without considering the presented questions. This results from their inadequate comprehension of the content they learned (Afandi et al., 2021). To improve this aspect, teachers can introduce case study or challenging problems that are relevant to the lesson material. In case-based learning, students are not only presented with problems but also encouraged to provide solutions. This supports the growth of students' abilities to identify, analyze, and propose solutions to complex problems in real-world situations (Ahmar et al., 2023). Case studies are often carried out by students in groups (Harris et al., 2020), which offers them the opportunity to contribute to the discussion, sharpening their abilities in evaluating definitions and proposing solutions.

The last aspect used to assess students' critical thinking ability is the aspect of strategy and tactics. This aspect is used to develop problem-solving plans (Astuti, 2021). This aspect's average percentage of 47.8% places it in the low category. In this aspect, students are required to offer suitable answers to an issue that the question poses. The low score in this aspect indicates that students are not yet capable of deciding on an action and choosing the right solution to solve a problem. Improvements in teaching can be made by involving problem solving, which encourages students to design strategies and solutions, aligning with the problem-solving indicator of identifying and selecting solutions (Handini et al., 2023). Teachers can assign exercises that push students to find solutions and assess them by reviewing and reconsidering the results, combining knowledge, and enhancing their problem-solving skills (Hery, 2017). There are several reasons for the low level of thinking ability among the pupils in this research. First, students tend to rely on memorization and rote learning of biology concepts, resulting in limited understanding (Agnafia, 2019; Ihsan et al., 2024). Students who only memorize concepts will find it difficult to use their expertise in novel or different situations. This also causes them to struggle when faced with questions that require critical thinking ability because they are not accustomed to such types of questions (Fauzi & Sa'diyah, 2019; Gustianingrum et al., 2023). Teachers need to accustom students to solving problems related to critical thinking, one of which is through HOTS (Higher Order Thinking Ability) questions. HOTS questions do not merely rely on memory but require students to process information, analyze, and think critically (Tim Pusat Penilaian Pendidikan, 2019).

Secondly, the use of learning models has not been fully optimized. Although conventional teaching still dominates, many teachers have tried to incorporate various learning models. However, these models have not been maximized in their ability to foster students' critical thinking abilities. This aligns with Syam et al. (2024), who pointed out that the suboptimal use of learning models is one of the reasons for the low levels of students' critical thinking abilities. Several factors contribute to this, such as inadequate facilities and infrastructure, limited time, and a lack of teacher knowledge and competence in implementing the chosen learning models (Harahap et al., 2024; Syahdia et al., 2024). Despite these challenges in implementing effective learning models, many researchers have shown that there are several models which, when applied correctly, can help address these issues and enhance students' critical thinking abilities. This aligns with the findings of Sidabutar & Mercuriani (2024), who noted that appropriate learning models are believed to be capable of improving students' critical thinking abilities.

For example, [Tafakur et al. \(2023\)](#) claimed that students' critical thinking ability may be effectively enhanced by the project-based learning approach. Another study by [Abdulah et al. \(2023\)](#) found that applying the problem-based learning approach helps enhance one's capacity for critical thought due to direct student involvement. Furthermore, [Anwar et al. \(2023\)](#) in their research also stated that the use of the discovery learning model can enhance students' critical thinking ability. Many other learning models are recommended by researchers to improve students' critical thinking ability, but it is important to note that the use of learning models must also be appropriate for the material and learning objectives to create a supportive learning environment for developing critical thinking ability.

Thirdly, the lack of student involvement in learning is another issue. According to [Mayarni & Nopiyanti. \(2021\)](#), students can cultivate critical thinking ability by engaging in a variety of activities that encourage thought. According to research by [Wandi et al. \(2023\)](#), the higher the level of student involvement in learning, the higher their critical thinking ability. Students can be actively involved during the learning process, such as by asking questions, seeking information, and conducting investigating ([Abidinsyah & Ramdiah, 2017](#); [Erdoğan, 2019](#); [Shamboul, 2022](#)) in his research stated that critical thinking ability can be developed by integrating them into the classroom through practical activities and exercises, such as presentations. Additionally, students can be involved in learning through group discussions, which encourage them to be more active by requiring them to share ideas and interact with each other. The participation of students in these discussions can enhance their critical thinking ability, as without these ability in learning, the process will only result in memorization ([Raihan & Malahayati, 2020](#); [Suhartoyo, 2017](#))

Fourthly, the minimal use of learning media in schools presents another issue. Studies carried out by [Musfikhuna et al. \(2021\)](#) indicate that learning media is one of the elements affecting students' capacity for critical thought. The more appropriate and effective the learning media used, the more it can enhance critical thinking ability. Learning media serve as resources for teachers to enhance the educational process ([Sulthon et al., 2021](#)). Utilizing learning media helps teachers communicate content to students more effectively. Additionally, throughout the learning process, educational media can act as a communication link between teachers and students, helping to convey information and concepts more effectively and efficiently ([Hidayati et al., 2024](#)). Currently, many studies recommend various learning media that can enhance critical thinking ability. One such study by [Isnaeni et al. \(2021\)](#) states that android-based learning materials are among the resources that might help students become more adapt at critical thinking such as e-booklets and webcomics. According to [Zuniari et al. \(2022\)](#) their research states that students' capacity for critical thought is positively impacted by augmented reality learning resources. [Hidayati et al., \(2024\)](#) also added that several types of various types of learning media, including simulation-based, game-based, and project-based media, can be utilized to improve critical thinking. Besides the aforementioned learning media, many other types of media can help improve critical thinking ability. The use of learning media must consider the appropriateness and relevance of the material to achieve the desired learning objectives.

Aspects of critical thinking ability that are still in the low and very low categories indicate a need for serious attention and action to improve these abilities to a better category. Efforts to enhance students' critical thinking abilities are crucial, considering that the ability to think critically is vital for students ([Septiany et al., 2024](#)). The role of teachers is vital in developing critical thinking ability, but cooperation and support from various related parties are also necessary to help improve these ability ([Agnafia, 2019](#)). Furthermore, to improve future outcomes, the instruments used to evaluate critical thinking abilities as well need to be updated with broader and more varied coverage. This is essential to ensure that researchers can capture a wider dimension of students' critical thinking abilities. Future research can also involve samples by adding more school variations, which can help identify factors that influence students' critical thinking abilities.

Conclusion

The capacity for critical thinking among high school students in Bantul Regency is categorized as very low in the aspects of elementary clarification and inference. Additionally, they are placed in the low category concerning the aspects of basic support, advanced clarification, and strategy and tactics. There are several reasons why students struggle with critical thinking, including biology learning that still relies on memory and rote learning, the lack of use of learning models that empower critical thinking ability, the insufficient participation of students in the learning process, and the minimal use of learning media. Various efforts are needed to improve these abilities through solutions that not only involve teachers but also various related parties. After the right solutions are put in place, it is expected that students' critical thinking ability will significantly improve, not only in academic fields but also in preparing students to face future challenges.

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Conflicts of Interest

The authors affirm that there is no conflicts of interest with respect to this paper's publication.

Author Contributions

E.M.S: composing the first draft in preparation, methodology and analyzed data, **E.Y:** review paper, editing and approval of the final version of the manuscript.

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