Students' Critical Thinking Skills on The Topic of Environmental Change

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Abstract: The 21st century is marked by globalization and rapid technological development, making critical thinking an essential skill. Incorporating biology into education is seen as a way to strengthen these abilities. However, many students still struggle with thinking critically, especially regarding environmental issues. This study assessed the critical thinking skills of 10th-grade students at SMA Negeri 4 Tanjungpinang during the 2023/2024 academic year. Using a descriptive approach, researchers evaluated 31 students through essay-based tests without altering any conditions. The analysis revealed that students' critical thinking was generally weak, particularly in areas such as giving basic explanations, reasoning, drawing conclusions, and providing deeper clarification. Nonetheless, they showed stronger performance in applying strategies and tactics. These findings highlight the need for teaching methods like problem-based learning to foster better critical thinking in students.

Keywords: 21th-century skills, critical thinking skills, environmental change, senior high school students.

INTRODUCTION

The 21st-century is known as the globalization era and the information technology advancement. Information is becoming very fast this century, and technological development is progressing rapidly. The increasing complexity of world problems, free competition, and uncertainty due to advances in technology and information are both opportunities and challenges faced by all areas of life, including the education sector (Nuzulia et al., 2023). The 21st century demands that humans possess a variety of abilities, such as the capacity to use technology, engage in critical thought, exercise greater creativity, and solve issues (Redhana, 2019). The 21st century is known as the industrial and knowledge century, and any attempts to develop abilities through self-education and meet different life necessities rely on the acquisition of knowledge through learning (Mardhiyah et al., 2021).

In the 21st century, the relationship between knowledge and learning is complementary and critical to an individual's success in the 21st century. Knowledge provides the foundation for understanding the world (Surajiyo & Winarni, R, 2021) while learning allows for adaptation and development of skills necessary to face the advances of the globalized age (Mashudi, 2021). This progress demands adaptive and innovative learning approaches to ensure that the knowledge gained is relevant and applicable in a real-world context. The ability to communicate, collaborate, think critically, and solve issues is known as "4C" learning in the twenty-first century. In this context, 4C learning poses a challenge, particularly for teachers who must innovate in developing knowledge in learning (Rini, 2022). In making an innovation in learning, the constructivism learning theory approach can be used (Wulandari et al., 2019) because in this theory, the teacher's task shifts from conveying knowledge to students to stimulating students' stimulus in interpreting knowledge in learning (Nurfaizah et al., 2022). Innovative learning greatly impacts how learning is carried out. To develop these innovations, cooperation is needed between the main components of learning so that learning can have optimal results (Hapsari & Fatimah, 2021). Learning comprises of students, teachers, and learning materials as its key components. Collaboration among educational elements can enhance students' ability to think critically. Learning that encourages students to practice improving their critical thinking skills would be perfect (Santosa et al., 2018). Therefore, to handle issues that come up in daily life, students are supposed to develop their critical thinking skills (S. Sundari et al., 2020). In the 21st century,

those are required to effectively solve problems in difficult situations (Rahardhian, 2022).

Critical thinking abilities are crucial as they will assist in addressing challenges in the 21st century through problem-solving. Hence, it is essential to foster critical thinking skills while students are in school. Students with these skills can see problems from multiple perspectives and develop better solutions, thus avoiding biases and errors that may arise when making decisions (Ariadila et al., 2023). Students who are trained in critical thinking skills tend to have better academic performance and can cope better with learning challenges (Mohamed & Sihes, 2021) as well as Stanikzai (2023) asserts that education that emphasizes critical thinking skills development can improve students' communication, teamwork, and self-management skills.

Related to critical thinking skills at the high school level, researchers have conducted observations at SMA Negeri 4 Tanjungpinang. Based on observations, the teacher stated that students still need to improve their critical thinking skills. Students still need help asking questions relevant to the material being taught, making it challenging to connect newly learned concepts with appropriate questions. In addition, when given questions about scientific topics, students still need help evaluating conclusions based on the relationship between relevant information, factors, and concepts, making it difficult to analyze a phenomenon. This aligns with the research of Hamdani et al., (2019), which shows that the need of the development of critical thiking skill due to the low level of these skills; it is due to the learning process, which is more focused on memorization, which will affect the results of student learning.

Students need to enhance their critical thinking skills to build their capacity to understand, assess, and analyze the information provided; this will help them build a more robust understanding of the subject matter and reduce the need for memorization. One of the materials in learning biology is environmental change. Environmental change is an essential topic in biology learning relevant to everyday life. Humans can change the environment, which can cause changes in the environmental system. The material is one of the materials that has a lot of memorization and broad concepts. This aligns with the opinion of Ruku & Purnomo (2020) that the material on environmental change is one of the materials that has much memorization, covers broad concepts, and can be applied to everyday situations. Critical thinking is needed regarding the problem of environmental change because students, as agents of future change, are the hope that can bring the environment in a better direction (Fernando & Sarkity, 2023; Liana et al., 2023; Sarkity et al., 2023a, 2023b). According to this explanation, students' critical thinking skills remain inadequate. Thus, students' critical thinking abilities must be assessed by connecting the subject matter to real-life scenarios (Susilawati et al., 2020). Therefore, it is necessary to research and analyze how students' critical thinking skills on environmental change material in biology learning.

METHODS

This study employs a descriptive research design aimed at illustrating a particular phenomenon through accurate data and consistent analysis (Sahir, 2022). A quantitative method was applied in this research. The subjects were 31 tenth-grade students from SMA Negeri 4 Tanjungpinang. The objective of the study was to examine students' critical thinking abilities in relation to environmental change. Data collection was carried out using a test instrument. The tool used consisted of five essay questions, each constructed based on Ennis's five indicators of critical thinking: basic clarification, foundation for decisions, inference, further clarification, and the application of strategies and tactics (Ennis, 1991; Sriliani, 2022). The arrangement of the questions in accordance with these indicators is presented in Table 1.

Table 1. Distribution of Questions based on Main Indicators

No	Indicator	Question Number
1	Basic clarification	1
2	The bases for the decision	2
3	Inference	4
4	Extended clarification	5
5	Strategies and tactics	3

The test used to evaluate students' critical thinking skills has been validated by experts and has been pre-tested. The validation results by experts show that the test that has been designed has a strong category and reliability, with the coefficient reaching 0.87 (strong category). Each

answer on the test is assessed based on a rubric that the critical thinking skills indicators have developed. The scoring system uses a 3-0 Likert scale with criteria presented in detail in Table 2.

Table 2. Critical Thinking Skills Assessment Rubric

Indicator		Assessment Rubric
Basic clarification	3	Create 3 problem formulations that lead to appropriate and precise answers in the subject matter.
	2	Make 3 problem formulations that almost lead to appropriate answers but are less precise in the subject matter.
	1	Able to make less than 3 problem formulations that lead to appropriate and precise answers in the subject matter.
	0	Inaccurate in formulating a problem that leads to an appropriate answer.
The basis for the decision	3	Able to identify 3 assumptions about the topic of the problems appropriately and accordingly
	2	Able to identify 3 assumptions about the topic of the problem, almost appropriate and appropriate but less precise in the subject matter
	1	Able to identify less than 3 assumptions about the topic that are appropriate and appropriate
	0	Inaccurate in identifying assumptions about the problem topic
Inference	3	Able to make complete conclusions according to the topic
	2	Able to make conclusions according to the topic but incomplete
	1	Incomplete in making conclusions
	0	Provides a conclusion but deviates from the topic
Extended clarification	3	Provide 3 appropriate solutions in line with the topic of the problem
	2	Provides 3 almost appropriate solutions in line with the topic of the problem
	1	Provides less than 3 solutions that are relevant to the problem's subject
	0	Does not provide a solution that fits the topic of the problem
Strategies and tactics	3	Provide 3 appropriate solutions in line with the topic of the problem
	2	Provides 3 almost appropriate solutions in line with the topic of the problem
	1	Provides less than 3 appropriate solutions in line with the topic of the problem
	0	Does not provide a solution that fits the problem topic

Students' critical thinking skills are then evaluated by comparing the scores obtained with the variation of score interpretations used by the teacher (Danaryanti & Lestari, 2018) presented in Table 3.

Table 3. Critical Thinking Skills Criteria

Criteria	Interval
Very High (VH)	$81,25 < x \leq 100$
High (H)	$71,5 < x \leq 81,25$
Medium (M)	$62,5 < x \leq 71,5$
Low (L)	$43,75 < x \leq 62,5$
Very Low (VL)	$0 < x \leq 43,75$

FINDING AND DISCUSSIONS

Students' critical thinking skills are measured through tests in the form of essay questions. The questions were given to 31 grade X high school students who had studied environmental change material. The assessment score is based on the rubric in Table 2. Every question serves as a gauge of critical thinking abilities. Five categories are created from the results of the student critical thinking skills test: basic clarification, the decision's foundation, inference, extended clarification, and strategies and tactics. The findings from the criteria-based analysis of research data are displayed in Table 4.

Table 4. Students' Critical Thinking Skills Description

No	Indicator	Average Student Score	Criteria
1	Basic clarification	57.0	L
2	The basis for the decision	49.5	L
3	Inference	37.6	VL
4	Extended clarification	45.2	L
5	Strategies and tactics	82.8	VH
	Average	**54.4**	**L**

According to the Table above, the average score for students' critical thinking skills falls within the low category at 54.4. When classified according to critical thinking abilities, students in the lower category demonstrate basic clarification skills, decision-making foundations, and extended clarification skills. Moreover, students are classified in the lowest category in the inference indicator. Skills in strategy and tactics indicators fall within the highest level of proficiency. Below is a description of the five critical thinking abilities students possess when studying environmental change topics. The categories of students' critical thinking skills can be observed in the Figure 1.

Figure 1. Percentage distribution of students in each category of critical thinking skills

The frequency distribution of categories representing students' critical thinking abilities is obtained from the graph above. It is known that the data shows that 6.5% of students fall into the very high category, 12.9% fall into the high category, 16.1% fall into the moderate category, 41.9% fall into the low category, and 22.6% fall into the very low category. Based on these findings, 41.9% of SMA Negeri 4 Tanjungpinang students showed low critical thinking skills. The following is an explanation of the outcome of each indicator.

1. Basic Clarification

Students' critical thinking skills on basic clarification indicators are measured by the questions shown in Figure 2. In this skill, the majority of students get a score of 2. Namely, students can make three problem formulations that almost lead to appropriate answers but are less precise in the subject matter, with a total of 13 students and a percentage of 42%. The details of the percentage of student scores can be seen in Table 5.

Table 5. Percentage of Student Scores on Basic Clarification Indicators

Score	Number of students (%)
0	29
1	0
2	42
3	29

Figure 2. Questions Related to Indicator of Basic Clarification

As shown in Table 5, no student answers get a score of 0. Student answers are only distributed in scores 1, 2, and 3. Examples of student answers for each score on Question 1 shown in Figure 3.

Figure 3. Example of Student Answers on Basic Clarification Indicators

Problem number 1 relates to the skill of identifying a basic clarification. The problem presented concerns forest and land fires, so ask and answer questions in the form of problem formulation. The category obtained by students in the basic clarification indicator is the low category. Some students need help understanding how to formulate a problem in a discourse. Students are known to be unable to identify a problem by formulating three questions about the discourse presented. This is similar to the results of previous research, which states that students need to be trained to identify and work on problems (Supriyati et al., 2018). Research conducted by Barasa (2022) stated that a factor that can cause students to be often unable to formulate problems well is a need for more understanding of the basic concepts needed to analyze problems critically. When these basic concepts are not well understood, students will have difficulty identifying essential elements in a problem and how these elements interact with each other. Basic clarification-making skills are essential skills in critical thinking. Some simple explanation-making skills include focusing on questions, analyzing questions, and answering questions about an explanation (Ayun et al., 2020). Students capable of this indicator must be careful when observing a question because it is inseparable from building basic knowledge and critical thinking skills (P. D. Sundari & Sarkity, 2021; S. Sundari et al., 2020).

2. The basis for the decision

The questions used to measure students' critical thinking skills as an indicator of the basis for the decision are shown in Figure 4. In this skill, most students scored 1, which means they could only recognize less than 3 suitable assumptions regarding the problem topic. 23 students, accounting for 74%, fell into this category. The distribution of students by score percentage can be viewed in Table 6.

Table 6. Percentage of Student Scores on Indicators of The Bases for the Decision

Score	Number of students (%)
0	0
1	74
2	3
3	23

Figure 4. Questions Related to the Indicator of The Bases for the Decision

There is no difference from the score distribution in question 1; student answers in question 2 also show that there are no students who got a score of 0, as shown in Table 6. Student answers are only distributed in scores 1, 2, and 3. Examples of student answers for each score on question 2 can be seen in Figure 5.

Figure 5. Example of Student Answers on the Indicator of the Bases for the Decision

Problem number 2 relates to students' ability to be the basis for the decision. The problem presented is related to an environmental condition that has few trees to assess how students determine the impact that occurs due to these problems. The category obtained by students on the indicator of giving reasons for a decision is low. Only a few students can provide reasons for making decisions based on analysing students' answers. Most other students only gave short and less detailed answers, and students should have mentioned other impacts of the small number of trees, such as the loss of habitat for wildlife. This aligns with the findings of the research results (Susilawati et al., 2020) which stated that some students answered correctly, but the answers presented were incomplete. The factor that can cause this is that some students have only a surface understanding of the material (Irani et al., 2020). Students can answer the question correctly but do not have in-depth knowledge to provide a more complete explanation. Giving reasons for a decision relates to how a person makes a decision based on logical and balanced thinking (Hidayati et al., 2021). This is based on how a person analyzes

arguments and evaluates evidence in a problem. In solving problems on biological material, students must possess a thorough comprehension of biological concepts. Therefore, these skills can continue to be improved by providing questions that stimulate students' critical thinking skills (Samaduri, 2022).

3. Inference

Students' critical thinking skills on the inference indicator are measured by the questions shown in Figure 6. In this skill, the majority of students, namely 13 students with a percentage of 42%, got a score of 0 because they gave conclusions outside the topic. Information regarding the distribution of student grades is shown in Table 7.

Table 7. Percentage of Student Scores on Inference Indicators

Score	Number of students (%)
0	42
1	16
2	23
3	19

Figure 6. Questions Related to the Inference Indicator

Different from students' answers to questions 1 and 2, students' answers to question 4 show a variation in scores ranging from 0 to 3.

Examples of student answers for each score on question 3 can be seen in Figure 7.

Figure 7. Example of Student Answers on Inference Indicators

Problem number 4 is related to the skills in making conclusions. The problem presented is

related to the waste problem. Students are asked to determine the conclusion in the discourse

presented. The category obtained by students in the conclusion indicator needs to be higher. Based on the analysis of students' answers, most students have yet to be able to make the correct conclusions from the problems presented. This aligns with research conducted by Wahyuni (2020), which states that students have yet to be able to conclude the problems presented in the problem. One factor that influences students' low critical thinking skills in the conclusion indicator is low metacognition. This is supported by research of Majid (2022) which states that students with low metacognition tend to be ineffective in identifying what they know and do not know, so they have difficulty making logical conclusions.

Skills in inference indicators involve integrating information, analyzing data, and evaluating arguments to reach a logical and reasoned conclusion (Linda & Lestari, 2019). To make reasonable and rational conclusions, one needs relevant information and an understanding of analyzing data and evaluating evidence. Students' ability to draw this conclusion falls in the lowest category, indicating that certain students have not fully grasped the concept. The ability of students to understand themselves about a problem presented also plays a role in how students can conclude a decision (Rahmayani & Fadly, 2022).

4. Extended Clarification

Students' critical thinking skills on extended clarification indicators are measured by the questions shown in Figure 8. In this skill, the majority of students score 1, and students provide less than 3 appropriate solutions to the topic of the problem, with a total of 25 students and a percentage of 81%. The details of the percentage of student scores can be seen in Table 8.

Table 8. Percentage of Student Scores on Extended Clarification Indicators

Score	Number of students (%)
0	0
1	81
2	3
3	16

Figure 8. Related Questions Extended Clarification Indicator

The distribution of scores in answers to question 5 is the same as the distribution of answers to questions 1 and 2; namely, no answers get a score of 0, which is different from the answers to question 3. Examples of student answers for each score can be seen in Figure 9.

Figure 9. Example of Student Answers on Extended Clarification Indicator

Questions related to further clarification are found in question number 5. The problems presented are related to problems related to land fires. The category obtained by students on the further clarification indicator is the low category. Further clarification is like providing a solution using criteria that follow the problem. In this indicator, questions are presented regarding the problem of the greenhouse effect, and students are expected to be able to come up with solutions based on a deep understanding of the information provided. One of the factors that causes the low category in the further clarification indicator is that students are not thorough in identifying a problem presented. This situation causes the ability to provide further clarification is not well achieved (Agnafia, D, 2019).

5. Strategies and Tactics

Students' critical thinking skills on strategy and tactics indicators are measured by the questions shown in Figure 10. In this skill, the majority of students scored 3, namely, students can provide 3 solutions that are appropriate and in accordance with the topic of the problem, with a total of 19 students and a percentage of 61%. The details of the percentage of student scores can be seen in Table 9.
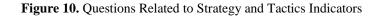
Table 9. *Percentage of Student Scores on Strategy and Tactics Indicators*

Score	Number of students (%)
0	0
1	13
2	26
3	61

Take a look at the following article to answer questions 3-4!
Plastic waste is an environmental problem faced by the world community. Plastic is considered very easy and practical. Not only that, the use of plastic that is only disposable is very short in time and more accessible to find anywhere. In addition to using plastic bags, we also encounter many plastic-based items such as household appliances, toys, and electronic devices with plastic materials. The use of plastic-based materials results in a high volume of plastic waste in the environment, and we can notice that there must be scattered around us. This can cause pollution in the marine environment. The scattered garbage will be carried to the sea and beaches through the ditches in the city that lead to the river; then, the plastic waste will flow into the sea. Plastic waste carried to the sea hurts ecosystems in coastal areas and marine organisms.
3. Give three solutions that you can come up with for these environmental problems!

Figure 10. Questions Related to Strategy and Tactics Indicators

Based on Table 9, it can be seen that the only answer that gets a score of 0 based on 5 questions is the answer to question 4. In question 3, the answers also show the same pattern as students' answers to questions 1, 2 and 5. Namely, the answers are only distributed at scores 1, 2, and 3. Examples of student answers for each score can be seen in Figure 11.

a. Do not throw garbage in the river
b. Do not throw garbage in the Java Sea
c. Do not throw garbage in the lake
1

- Using biodegradable or environmentally friendly items
- No longer use plastics that are difficult to decompose
- Discipline and compliance are key
2

- Recycling plastic waste
- Bring your shopping bag
- Avoid buying food or drinks in plastic packaging
3

Figure 11. Example of Student Answers on Strategy and Tactics Indicators

Question number 3 is related to strategy and tactical skills. The problem presented is about the large amount of plastic waste used. The category obtained by students on the strategy and tactics indicators is very high. Based on the analysis of the students' answers to question number 3, most students determine the right strategies and tactics to solve the problems they face. However, some still provide strategies and tactics that need to be revised. Students need to provide a straightforward solution to solve the problem. For example, students only provide a solution by not throwing garbage. However, further explanation is needed about other alternatives that can be taken to overcome the problem. The ability of students to select the correct actions to solve a problem is connected to their expertise in developing strategies and tactics (Facione, 1990). The teacher's responsibility in cultivating students' ability to think critically

during their education can also be done with basic questions, then building the ability to draw conclusions, synthesize and evaluate skills (Acharya, 2018). Improving these skills can help to overcome obstacles and enhance the teaching and learning process in the future.

In general, students' critical thinking skills on environmental change materials are in a low category compared to the average score obtained by students. Thus, these are essential to be trained because students with these skills can think based on their experience, solve problems effectively, and make decisions that align with their findings Students' mastery of the concept of the material learned also affects their critical thinking skills. Therefore, it is important to keep in mind that every type of critical thinking is valuable and impossible to do without the main component, which is knowledge (Ramdani et al., 2020). Based on the results and discussion of students' critical thinking skills based on 5 indicators, it can be seen that there needs to be improvement in students' critical thinking skills, especially in environmental change material. Several studies have shown that implementing certain learning models can improve critical thinking skills, including Problem-Based Learning (Boleng & Maasawet, 2019; Don, 2020; Puspita & Aloysius, 2019), inquiry learning (Saekawati & Nasrudin, 2021; Suwono et al., 2023), PBLPOE (Fitriani et al., 2020), etc. Apart from that, critical thinking skills in biology learning can also be improved by developing teaching materials (Kusmaharti & Yustitia, 2022; Marnah, 2022; Syafril & Kurniawati, 2021).

CONCLUSION

Based on the analysis of students' critical thinking skills in environmental change materials, the highest score was obtained in the strategy and tactics indicators, with a score of 82.8 (very high category). A basic clarification followed this, as did the skill of the bases for the decision and extended clarification with scores of 57.0, 49.5, and 45.2 (low category). Meanwhile, students' skills in inference with a score of 37.6 (very low category). The average student's critical thinking skills are generally in the low category (score 54.4). These students' low critical thinking skills prove that these skills need to be improved and trained in implementing biology learning. One of the ways to improve students' critical thinking skills is by applying certain learning models or developing teaching materials

that can support improving students' critical thinking skills. Because of the importance of this skill, all solutions provided are worth considering to overcome student problems related to critical thinking skills.

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