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Critical Thinking and Students Scientific Epistemological Beliefs

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ABSTRACT

This study investigated the critical thinking skills and Science Epistemological Beliefs (SEB) of grade VII students at an Islamic boarding school in MTsN 1 Sidoarjo, Indonesia. Using a descriptive quantitative approach, data were collected through a critical thinking skills test and a SEB questionnaire. The analysis revealed that the highest critical thinking indicators were basic classification, strategy, and tactics, demonstrating good performance. However, the justification indicator for SEB was notably low, highlighting gaps in students' understanding of scientific concepts. Overall, students exhibited moderate critical thinking skills, underscoring the need for strategies to enhance critical thinking and epistemological understanding.

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1. INTRODUCTION

The learning process has a role in preparing students to face challenges in this century. Entering the 21st century, learning is experiencing a transition from teacher-centered learning to student-centered learning (Haniyah, 2022). To play a meaningful role in this century, students must have 4 skills including communication skills, critical thinking skills, problem-solving skills, as well as collaboration between these 3 skills. Improving critical thinking skills is very important because with these skills students can achieve a deep understanding of the material learning.

The curriculum is currently being used in 21st-century learning. The independent curriculum has an approach where students are made learning centers. An independent curriculum provides freedom to both students and student teachers in carrying out learning. The independent curriculum aims to realize holistic and contextual learning (Anton & Trisoni, 2022). Holistic learning is learning that develops all students' skills. Temporary Contextual learning teaches students to connect everything they learn with everyday life (Zubaidah, 2020).

Critical thinking skills are students' skills in analyzing information critically (Djaja *et al*., 2023). According to Ennis, critical thinking indicators are divided into 5 categories: basic classification, the basis for decision-making, inference, advanced classification, strategy, and tactics. The five indicators are then classified into several sub-category's indicators, such as basic classification indicators into 4 sub-indicators, basic indicators decision making into 3 sub-indicators, inference indicators into 4 sub-indicators, advanced classification indicators into 6 sub-indicators, and strategy and tactics indicators into 1 sub-indicator (Ennis, 2015).

Like science, it is explained that the basic understanding of science includes three important components. The three components are science as a product, process, and attitude (Manik *et al*., 2023). Critical thinking is a form of science as a process because critical thinking is the process of students acquiring in-depth knowledge. While form science as an attitude is in Science Epistemological Beliefs (SEB). Where SEB is students' confident attitude towards the knowledge gained during learning (Kampa *et al*., 2016).

SEB are students' beliefs about the basis of something knowledge. SEB indicators according to Conley are divided into 4, including certainty, source, development, and justification (Zhao & Liu, 2021). The four indicators are closely related to each other because to believe in the basis of knowledge requires the credibility of the source of that knowledge. The source of knowledge can be a teacher's explanation as well as other sources such as books and the internet (Nariswari *et al*., 2022).

Critical thinking is related to SEB because in 21st-century learning students not only emphasize having high knowledge but also having skills and a good attitude. Critical thinking is a form of skill and an internal process to gain knowledge (Ningrum, 2022). SEB is a form of attitude that students must have during learning and after learning is implemented (Schiefer *et al*., 2022).

In reality, the results of critical thinking skills and SEB of Indonesian students are low, proven by the results of the critical thinking ability and SEB tests of MTsN 1 Sidoarjo students with an average of 46.56 and is in the sufficient category. Research also stated that students' critical thinking abilities on Order Thinking Skills questions are low and do not at all meet the critical thinking indicators according to Perkins and Murphy (Prasetyo & Firmansyah, 2022). Meanwhile, junior high school students have low critical thinking abilities with varying percentages for each indicator (Solikhin & Fauziah, 2021).

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This research aims to determine the critical thinking and science skills for SEB of class VII students at MTsN 1 Sidoarjo.

2. METHOD

This research used a descriptive quantitative approach. In this study, we used the steps described in **Figure 1**. The research was carried out at the Islamic Boarding School in MTsN 1 Sidoarjo, Indonesia, for VII-grade students. This research used a purposive sampling technique with the provision of the class with the highest average score (Ramdani et al., 2021). The research was conducted in one class, namely class VII-A, with students who obtained a high average score according to the initial grouping test conducted by the school.

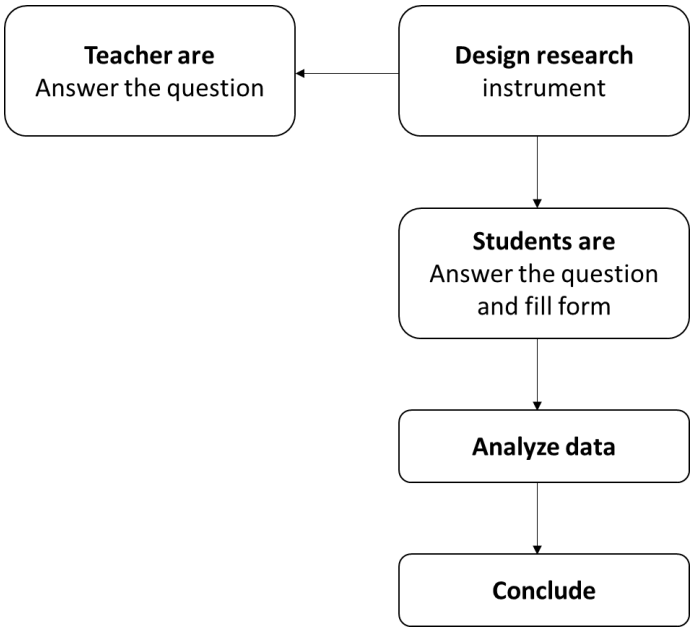

Figure 1. Research flow.

Instruments used to measure critical thinking skills in research This is a critical thinking ability test and SEB questionnaire. The thinking ability test instrument Critical contains 10 multiple-choice questions. Each multiple-choice question item has been adjusted by researchers with critical thinking indicators by Ennis. The test results are then analyzed for known to be the highest indicator of critical thinking. The distribution of critical thinking indicators in questions is shown in **Table 1**. The list of the questions is shown in **Figure 2**.

Table 1. Critical thinking indicator.

Critical Thinking Indicator	Question Number
Basic Classification	1 and 2
Bases for a Decision	3 and 4
Inference	5 and 6
Advanced Classification	7 and 8
Strategy and Tactics	9 and 10

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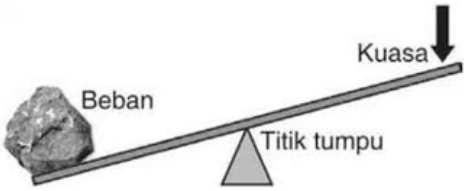


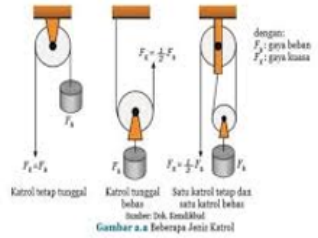
(i) A lever is used to lift a load weighing 500 N (see **Figure 2**). If the distance from the fulcrum to the applied force is 1.5 m and the distance from the fulcrum to the load is 0.5 m, is this system in equilibrium? Explain your reasons!

(ii) When building a house, humans need a ladder to reach the high part. Or to transport heavy building materials in assembling the walls of the house. These simple tools in science are called simple machines.
From the statement above, what is meant by a simple machine?

(iii) Based on the results of observations by group A in the school environment, the following data was obtained: Scissors, Seesaw, Pecan crackers, Stapler, Bottle opener, and Tweezers. After you observe the data. Group the tools according to the type of lever!

(iv) A student uses an inclined plane to lift a load of 100 N with a force of 40 N. He stated that using an inclined plane makes it easier to lift the load. Based on your knowledge, what can you conclude about the efficiency of the inclined plane?

(v) In an experiment, student C used two pulleys to lift a load of 60 N and found that the force required was 30 N. Student C concluded that "Every time the number of pulleys increases, the force required will always decrease by half." Is this conclusion correct?



(vi) Kevin experimented with pulleys and found that every time he used a movable pulley, he could lift a heavier load with less force. Kevin concluded that "All movable pulleys will always reduce the force required." What is your assessment of this argument?

(vii) A pulley is a tool used to move a load by changing the direction of the applied force. Based on this definition, what is the function of a pulley?

(viii) If an inclined plane is designed at a lower angle, what can you assume about the force required to lift the load?

(ix) In explaining the material about levers, a teacher said "Imagine how much energy we can save if we use levers to lift heavy loads?" In the statement, what strategy does the teacher use?

(x) Rudi is a worker at the port. In this condition, Rudi needs to lift a load of 200 N to a height of 2 meters. He has the choice between using a double pulley or a lever with a length of 1.5 meters. From the narrative, what should he consider to determine which tool is more efficient?

Figure 2. List questions.

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The instrument used to measure SEB in this study was Conley's questionnaire method. The questionnaire instrument contains 25 statement items. In that statement, students were asked to rate on a scale of 1-4 with the information 1 = strongly disagree; 2= no agree; 3= agree; 4= strongly agree. This statement has been adapted by researchers SEB indicator. The distribution of SEB indicators in the questionnaire is shown in **Table 2**.

Table 2. SEB Indicator.

SEB Indicator	Question Number
Certainty	1-5
Source	6-11
Development	12-16
Justification	17-25

Another instrument used by researchers is an interview instrument. Interviews were conducted to determine students' critical thinking abilities and SEB from the perspective of the science subject teacher instructing in that class. The interview instrument contains 9 questions that the researcher has adapted to indicators of critical thinking and SEB.

The results of the critical thinking ability test and SEB questionnaire were analyzed statistically descriptively. Meanwhile, the interview results were analyzed descriptively and qualitatively. Test results and questionnaires are categorized according to indicators. Indicator categories are shown in **Table 3**.

Table 3. Category.

Category	Question Number
Very Low	1-19
Low	20-39
Enough	40-59
Good	60-79
Very Good	80-100

3. RESULTS AND DISCUSSION

Students' critical thinking skills are measured using critical thinking tests adjusted to critical thinking indicators according to Ennis. These indicators include, among others basic classification, basic decision making, advanced classification, inference, and strategy and tactics. The results of the analysis of the critical thinking skills of MTsN 1 Sidoarjo students are shown in **Table 4**.

Table 4. Critical thinking result.

Critical Thinking Indicator	Score	Category
Basic Classification	66.67	Good
Bases for a Decision	33.33	Low
Inference	16.67	Very Low
Advanced Classification	50.00	Enough
Strategy and Tactics	66.67	Good

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Based on **Table 4**, the critical thinking indicator that achieved the highest score is the basic classification indicator. Basic classification indicators refer to students' abilities to explain information based on students' initial perceptions. These indicators achieve a score of 66.67 and are in a good category.

Other critical thinking indicators that achieved the highest scores were strategy and tactics. Strategy and tactics indicators refer to students' skills in strategy and tactics that students use when carrying out learning. The indicator gets a score of 66.67 in the good category. These strategies and tactics influence the way students earn knowledge in learning. This indicator is very important in making learning more meaningful (Ningrum, 2022).

Advanced classification is an indicator of critical thinking that gets a score of second highest. This indicator gets a score of 50 in the sufficient category. Indicator Advanced classification refers to students' ability to explain more information deeply. These skills require students to correlate existing knowledge (Sundari & Sarkity, 2021)**.**

The basis for decision making is an indicator of critical thinking which gets the third highest score. This indicator received a score of 33.33 in the low category. Basic indicators of decision-making refer to the student's process of gaining knowledge. This process can take the form of on-site observations or digital observations (Pujiyanto, 2021).

The critical thinking indicator with the lowest score is the inference indicator. The inference indicator got a score of 16.67 in the very category. Inference indicators refer to students' ability to conclude the knowledge they have obtained after learning. MTsN 1 Sidoarjo students have low critical thinking skills on inference indicators.

SEB was measured using the SEB questionnaire which was adapted to the SEB indicator according to Conley. These indicators include certainty, source, development, and justification. The results of the SEB analysis of MTsn 1 Sidoarjo students are shown in **Table 5**.

Table 5. SEB Result.

SEB Indicator	Score	Category
Certainty	16.33	Very Low
Source	18.33	Very Low
Development	14.33	Very Low
Justification	30.33	Low

The indicator with the highest score is the justification indicator. Indicator This achieved a score of 30.33 and was included in the low category. Justification indicators refer to the student's process of receiving knowledge (Irhasyuarna *et al*., 2022).

The source is an indicator that received a score of 18.33 in the very category of not enough. Source indicators refer to students' beliefs about the source of something knowledge. Sources of knowledge can be in the form of teacher explanations books or other sources (Riku, 2021).

Certainty is an indicator that received a score of 16.33 in the very category not enough. The certainty indicator refers to students' confidence in knowledge that knowledge is absolute. Knowledge is absolute, meaning knowledge does not change and is not affected by developments over time (Amanullah, 2020).

The indicator that gets the lowest score is the development indicator. The development indicator scored only 14.33 in the very low category. Development indicators refer to students' confidence in recognizing development science. MTsN 1 Sidoarjo students have low SEB in all four indicators, especially on development indicators.

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4. CONCLUSION

The indicators are critical thinking, and basic classification obtained the highest score of 66.67 in the good category. Indicators of the basis for decision-making received a score of 33.33 in the low category. Indicator inference got a score of 16.67 in the very low category. Classification indicators Advanced gets a score of 50 in the sufficient category. Meanwhile, strategy and tactics indicators got a score of 66.67 in the good category, the same as the basic classification indicators. The SEB certainty indicator received a score of 16.33 in the very low category. The source indicator received a score of 18.33 in the very low category. Indicator development received a score of 14.33 in the very low category. Indicator's justification obtained a score of 30.33 in the low category. From the conclusion above, we can see that the critical thinking skills of SEB MTsN 1 Sidoarjo Class VII students are very low. Follow-up efforts need to be made to improve the critical thinking and SEB skills of MTsn 1 Sidoarjo students, especially class VII.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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