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Junior High School Students' Critical Thinking Skills and Concept Mastery on Energy Topic

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Abstract: Using quantitative descriptive methods in the form of critical thinking skills tests and concept mastery, this study intends to ascertain the profile of critical thinking skills and concept mastery of junior high school students on energy and its changes. The average score of students on the test was 36.60 out of 100. Students averaged 29.86 on the indication of providing a basic explanation, 29.79 on the indicator of drawing a conclusion, and 28.35 on the indicator of providing a more thorough explanation. Critical thinking abilities are among the things that all three lack. The concept mastery test scores for the cognitive domains of analyzing (C4) and evaluating (C5) were, on average, 35.72 and 34.62, respectively, placing the students in the intermediate range. The findings indicated that due to students' low literacy regarding energy and its changes, their inexperience with working on higher-level thinking questions, and their use of less varied learning methods, their critical thinking skills were in the poor category and their concept mastery was in the moderate category.

Keywords: Concept mastery; Critical thinking skills; Energy and its changes; Profile of junior high school students

Introduction

Education educates people to think critically, creatively, and independently and is the vital component of high-quality human development (Rusmansyah et al., 2023). It also enhances the quality of a nation's Human Resources (HR) in a variety of sectors. The development of critical and creative thinking abilities in Junior High School (SMP) Natural Science (IPA) courses is a vital component of the educational system (Warmadewi, 2022). Students can build information and concepts, develop scientific skills, process skills, and use critical thinking to solve real-world problems by studying natural science (Khasani et al., 2019).

The issues of living in the twenty-first century are faced by education today (Sawu et al., 2023). According to Jamaluddin et al. (2019), the education system needs to be able to raise the standard of instruction in order to produce capable people who can meet the demands of the twenty-first century. Science and technology have advanced quickly in the twenty-first century, particularly in the field of information and communication technology (Astiti et al., 2021). In this regard, creating Human Resources (HR) with the competencies required to meet a variety of life's issues is a crucial task for education (Bogar et al., 2024). People with strong moral principles, the ability to solve problems and think critically, creatively, and methodically are considered high-quality human resources (Hidayati et al., 2021).

Permendikbud No. 21 of 2016 places a strong emphasis on teaching 21st-century skills. According to Agmita et al. (2021), the ability to reason, process, and exhibit practical, creative, productive, critical, autonomous, collaborative, communicative, and solution-oriented skills in both concrete and abstract domains is emphasized in secondary education's core competencies. Students are required to possess competencies in 21st-century learning that will allow

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them to succeed in the globalized environment (Susilowati & Wisanti, 2023). Critical thinking is one of the abilities that students must acquire (Samsudin et al., 2024).

Critical thinking, creativity, communication, and cooperation are among the 21st-century talents, sometimes referred to as the 4Cs in the context of education (Agmita et al., 2021). The four Cs are defined as follows: communication skills involve expressing ideas and information both orally and in writing; collaborative skills include practical cooperation, respect for diversity, language proficiency, shared decision-making, and leadership; critical thinking skills are defined as critical problem-solving abilities; and creative thinking skills are the application of innovative approaches in problem-solving (Sari et al., 2021).

In Fatimah (2024), Depdiknas (2011) asserts that scientific education should be planned to help students comprehend science and technology, cultivate critical, logical, and creative thinking abilities, and practice thinking holistically when addressing a variety of real-world issues. In the twenty-first century, students need to be proficient in critical, creative, communicative, and collaborative thinking (Azmi et al., 2021). Here, individuals must use their knowledge to solve problems in a creative and critical manner (Agmita et al., 2021; Yuliarti et al., 2023).

According to Nurmasyitah et al. (2023), critical thinking is a process of learning in which pupils evaluate in order to form conclusions or solve problems. Critical thinking is a high-level thinking domain that can and should be taught continually. Critical thinking skills are attitudinal talents that a person employs to evaluate an issue (Gunada et al., 2023). Robert Ennis (1993) identified indicators of critical thinking abilities as the capacity to offer basic explanations, cultivate foundational knowledge, use deductive reasoning, offer sophisticated explanations, and identify approaches and maneuvers (Pamorti & Suryandari, 2024). In junior high school science classes, critical thinking abilities are stressed. These skills require students to be able to analyze data, assess claims, and have a thorough comprehension of scientific ideas. Students that possess critical thinking abilities are better able to comprehend and evaluate issues in order to meet learning objectives (Darmaji et al., 2020; Maison et al., 2022).

Suparno (2013) in Algiranto et al. (2021) states that a learning model that encourages students to learn actively and take initiative is necessary for the development of critical thinking abilities. A classroom that is interactive and where teachers engage as mediators, facilitators, and motivators who assist students in the learning process rather than merely providing instructions is necessary to achieve the best possible learning outcomes for students' essential abilities (Nuryanti et al., 2018).

Natural Science (IPA) is a series of concepts, laws, principles, or theories produced through a creative and systematic process through investigation followed by continuous observation (Muna & Linuwih, 2023). Knowledge in science can include mastery of concepts related to natural knowledge itself. According to Firmansyah et al. (2022) and Desstya (2016), mastery of concepts includes student skills not only to understand but also to explain the concepts given in solving a problem, even when facing new concepts. The meaningfulness of concept mastery in supporting and developing all student potential needs to be a focus in the learning process (Pursitasari & Heliawati, 2022). It is intended for students to achieve optimal learning outcomes, with concept mastery as the main foundation (Nugraha & Awalliyah, 2016). One of the assessment components in a learning process is the evaluation of concept mastery. The goal is to assess students' ability to accept and understand the concepts taught in the learning process. Concept mastery plays an important role in learning because, through this understanding, students can holistically develop their abilities at every learning stage (Sintiawati et al., 2021).

The critical thinking abilities and concept mastery of the pupils at SMP Negeri 03 Belitang Madang Raya have never been the subject of research. Low student learning outcomes were found in the formative assessments on energy and its changes in class VIII, so the researcher decided to use energy and its changes as research material. The study's findings will demonstrate the degree to which junior high school students grasp, apply, analyze, and assess concepts related to energy and its variations, as well as how well they employ critical thinking abilities. When creating instructional activities that foster students' critical thinking abilities and conceptual mastery, educators can use the study's findings as a guide. In order to prepare today's youth to make responsible energy-related decisions in the future, science education is essential (Yusup, 2021). In current era of globalization, communication and information have high speed and limitless access, claim Chairatunnisa et al. (2023). The development of critical thinking abilities in pupils is crucial to preparing them to function in society. As a result, this study can offer pertinent data that can further educational progress.

Method

The methodology used in the research is descriptive quantitative. The descriptive method applied in designing this research aims to describe the phenomenon or condition according to the actual

situation without changing (Azmi et al., 2021). Eighth grade students from SMP Negeri 03 Belitang Madang Raya, one of the first driving schools in the East Ogan Komering Ulu district to implement an independent curriculum, made up the population of this study, which consisted of five randomly selected classes out of a total of 135 students in the school year 2023–2024. The research flow is depicted in Figure 1 below.

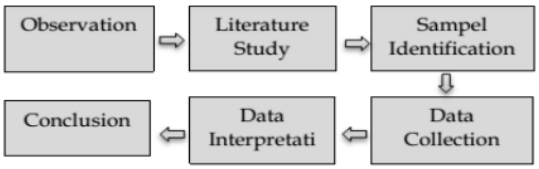

Figure 1. Research flow

Two approved instrument types are used in the data gathering technique: tests of critical thinking abilities and concept mastery. There are twelve multiple-choice questions in the Energy and its Changes curriculum that assess students' critical thinking abilities and conceptual comprehension. The questions are designed to be indicative of critical thinking.

According to Robert Ennis, the test questions in this study were created with consideration for critical thinking abilities and were taken from Purnomo, 2020.

Table 1. Indicators of Critical Thinking Ability

Critical Thinking Indicators	Critical Thinking Sub-Indicators
Elementary clarification	Focusing the question.
	Analyzing the question.
	Ask and answer questions/challenges.
The basis for the decision	Considering whether the source is trustworthy.
	Observe and consider an observation report.
Inference	Deduce and consider the results of the deduction.
	Induce and consider the results of induction.
Advances clarification	Create and determine the consideration value.
	Define terms and consider definitions in three dimensions.
	Identifying assumptions.
Supposition and integration	Determine actions interact with others.

The data collection method uses two types of authorized instruments: concept mastery and critical thinking assessments. The Energy and its Changes curriculum consists of twelve multiple-choice questions designed to evaluate students' critical thinking skills and conceptual understanding. The purpose of the questions is to demonstrate critical thinking.

Robert Ennis claims that the test questions used in this study were derived from Purnomo, 2020, and were written with critical thinking skills in mind.

$$NP = \frac{\sum \text{Score Obtained}}{\sum \text{Maximum Score}} \times 100 \quad (1)$$

Additionally, the criteria table for the degree of critical thinking skills that was adopted from Rahmawati et al. (2023) was adjusted by the researchers into the following five categories in order to classify students' critical thinking abilities.

Table 2. Criteria for Critical Thinking Ability

Category	Value Range
Very Good	81 – 100
Good	61 – 80
Fair	41 – 60
Less	21 – 40
Very Poor	0 – 20

Then, to determine the category of student's mastery of concepts, researchers used an adapted concept mastery criteria table as follows.

Table 3. Criteria for Concept Mastery

Category	Value Range
Low	0 – 33.33
Medium	33.34 – 66.67
Hight	66.68 - 100

Result and Discussion

Critical Thinking Ability

Data collection was conducted on March 25-27, 2024, on 135 students of class VIII face-to-face at SMPN 03 Belitang Madang Raya. A total of 12 multiple-choice questions representing five indicators of critical thinking ability and two cognitive domains of concept mastery were given through Google Forms at https://tinyurl.com/TesKPKPK. Students provide answers directly on the Google form page using the link. After data collection was complete, the researcher analyzed the test data.

At SMPN 03 Belitang Madang Raya, data student responses have been collected and evaluated to ascertain the profile of critical thinking abilities and conceptual mastery of energy and its changes. Finding the maximum, minimum, standard deviation, and average value (mean) is the first step in data analysis.

After that, the computation results are categorized according to the five categories Table 2 shows for students' critical thinking abilities. Table 4 below displays the findings of the data analysis of the student's critical thinking abilities exam.

Table 4. Test Result

Category	Value
Maximum Value	91.67
Minimum Value	8.33
Average Value	36.60
Standard Deviation	14.44

The distribution of test score data on the critical thinking ability category can be seen in Table 5 below.

Table 5. Data Distribution of Critical Thinking Test Result

Category	Value Range	Number of Students	Percentage (%)
Very Good	81 – 100	1	0.74
Good	61 – 80	3	2.22
Simply	41 – 60	59	43.70
Less	21 – 40	52	38.52
Very Less	0 – 20	20	14.81

Table 5 shows that the class VIII students at SMPN 03 Belitang Madang Raya scored an average of 36.60 on the critical thinking ability test, placing them in the Lack group. Then, out of 135 pupils, 91.67 was the highest score and 8.33 was the lowest. Table 5 shows that just one student falls into the Very Good category for critical thinking abilities, whereas the majority of the 59 students (43.70%) go into the Fair category, and 52 students (38.52%) fall into the Lack category.

The average value for each critical thinking ability indication is derived from the average test results, as seen in Figure 2 below.

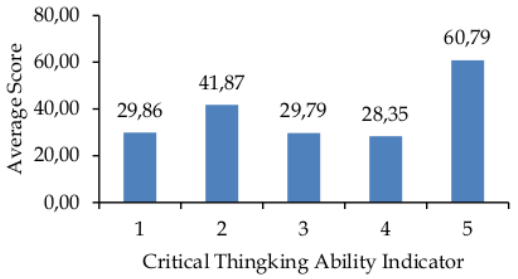

Figure 2. Graph of average critical thinking ability test scores of junior high school students

The Ennis framework, which has five indicators—giving clear explanations, developing necessary abilities, drawing conclusions, providing more explanations, and organizing strategies and tactics—is used in this study on critical thinking skills. Figure 2 shows that the fifth indicator, arranging strategies and tactics, had the greatest average score of students at 60.79, while the fourth indicator, providing further explanation, had the lowest average score of students at 28.35.

The test data for this study came from the analysis of the critical thinking ability test taken by 135 students in class VIII at SMPN 03 Belitang Madang Raya. The test consisted of 12 multiple-choice questions that were designed to assess critical thinking skills. Following that, the responses from the students are examined and categorized according to the critical thinking skill category. Essential thinking skills go into five categories: outstanding, good, sufficient, less, and much less. Additionally, it examined students' idea mastery abilities using three concept mastery criteria: low, medium, and high.

Students in class VIII SMPN 03 Belitang Madang Raya are categorized into five groups according to their critical thinking abilities: very good, good, simple, less, and very less. These groupings are based on the results of data analysis. According to Figure 2's graph, the average score of student test results for all critical thinking skill indicators is less than 6. In specifics, the average value achieved is 29.86 for the indicator providing a basic explanation, 29.79 for the indicator ending, and 28.35 for the indicator providing a more thorough explanation. It can be said that none of the three has strong critical thinking abilities. With an average value of 41.87 and 60.79, respectively, the indicators of arranging strategies and tactics and developing fundamental abilities fell into the category of sufficient critical thinking skills.

Indicators of Critical Thinking Skills with the Lowest Average Score

Natural Science (IPA) contributes to the development of conceptions, the advancement of knowledge, and the encouragement of scientific inquiry. According to Khazani et al. (2019), this lesson can help promote process skills and the capacity for critical thought while addressing difficulties in daily life. In Chairatunnisa et al. (2023), Depdiknas (2011) states that in order for students to study science and technology, they must be exposed to teaching approaches that enable them to think critically, logically, and creatively. Furthermore, the learning objective is to empower students to apply critical thinking to address a range of real-world issues. One of the most important components of modern learning is the ability to think critically (Chairatunnisa et al., 2023).

Giving further explanation is the fourth indicator, with the lowest average score of 28.35 (Poor category) on the critical thinking skills test. The two sub-indicators that make up the indicator of developing fundamental abilities are defining terms, taking definitions into account in three dimensions, and recognizing assumptions.

This fourth indication uses two questions as its question format. After reading a story, students are required to define the phrase "energy transformation" and consider how it might be used in real-world situations in three dimensions in the first problem. As a result, students' average critical thinking abilities score of 27.32 falls into the Lack group. Using option D as the average student response, Class VIII B received the lowest average score of 13.64. The idea of energy transformation states that although energy's form changes, the system's overall energy content stays unchanged. Students don't seem to be as critical when it comes to identifying energy transformation and distinguishing it from the idea of the rule of conservation.

The second question contains a number of assertions that are presumptions that affect how the Law of Conservation of Energy applies to the energy transformation of incandescent bulbs. Students are required to list the presumptions pertaining to the Law of Conservation of Energy's relevance to the energy transition of incandescent lights. As a result, students' average critical thinking abilities score of 29.37 falls into the Lack group. With an average score of 16.67 in the Very Poor category, Class VIII D received the lowest overall, indicating that students are much less adept at recognizing assumptions.

Basically, students can answer the questions given, but they are still unable to explain and analyze them effectively. Difficulty in processing question analysis can be caused by several factors, including limitations in reading ability and interest (literacy), discomfort in finding reasons for answers to problems at hand, and environmental influences such as distractions from friends while trying to answer questions, resulting in a lack of student concentration (Hidayati et al., 2021).

Indicators of Critical Thinking Skills with the Highest Average Score

Critical thinking involves the ability to deeply gather the correct information (Hidayat et al., 2019). Critical thinking refers to the ability to reflect before making decisions, solving problems, or receiving information. This is done based on proper, logical, objective, and careful reasoning. A person who has critical thinking skills can perform examination, critical questioning, in-depth understanding, analysis, judgment, evaluation, and the ability to correct and reconstruct carefully. It is a skillful combination of knowledge, skills, and attitudes.

The highest average critical thinking test score data of 60.79 (Very Good category) is on the fifth indicator, namely organizing strategies and tactics. The indicator of organizing strategies and tactics consists of 2 sub-indicators, namely determining actions and interacting with others. The form of questions presented in this fifth indicator is two questions.

In the first problem, a story is presented, and then students are asked to determine and plan actions that support the need to find sustainable energy alternatives. The result is that the average student score of 53.58 is in the Fair category for critical thinking skills. Overall, students are quite capable of determining and planning actions that support the need to find sustainable energy alternatives.

In the second question, students were asked to analyze how to interact with others regarding the concept of renewable energy appropriately. The result is that the average student score of 68.01 is in the Good category for critical thinking skills. It can be seen that, overall, students are able to determine and plan actions that support the need to find sustainable energy alternatives.

When all indicators were taken into account, the results showed that 0.74% of students received scores in the Very Good category, 2.22% in the Good category, 43.70% in the Fair category, 38.70% in the Poor category, and 14.81% in the Very Poor category. It is evident that the majority of SMPN 03 Belitang Madang Raya's VIII grade pupils still struggle with critical thinking. The overall average score on the exam of students' critical thinking abilities is 36.60, which places them in the category of having inadequate critical thinking abilities. According to research on the development of critical thinking abilities, teachers who implement an efficient learning process, make simultaneous use of the diversity of disciplines, and assist students in producing products during the learning process can help students' critical thinking abilities to advance (Evcim & Arslan, 2022). Additional studies indicate that tying academic ideas to students' real-world experiences helps enhance their critical thinking abilities (Ananda et al., 2023).

Concept Mastery

In order to meet learning objectives, a critical stage in science education is conducting a concept mastery analysis. According to Permendikbud (2016), students must possess understanding of factual, conceptual, procedural, and metacognitive aspects of science. Additionally, remembering (C1), comprehending (C2), applying (C3), analyzing (C4), assessing (C5), and producing (C6) are among the cognitive characteristics of concept mastery, according to Anderson et al. (2001) in Bohori et al. (2019).

Understanding definitions, differentiating one idea from another, and elucidating a concept's significance in relation to daily life are all necessary for mastering scientific (physics) concepts. The development of higher-level thinking abilities in the formulation of principles

and generalizations requires this as a fundamental building block (Nurkasma et al., 2022).

In order to ascertain the profile of students' concept mastery in accordance with the three criteria for concept mastery, the study's student answer data were also examined. In order to perform the study, the questions were grouped based on the cognitive domains of analyzing (C4) and evaluating (C5). The average value was then determined. Table 3 then groups the computation results according to the idea mastery criterion. Table 6 below displays the findings from the data analysis of the conceptual mastery of the pupils.

Table 6. Data on Concept Master Results

Cognitive Domain	Average Value	Category
Analyze (C4)	35.72	Medium
Evaluate (C5)	34.62	Medium

The information in Table 6 shows that the SMPN 03 Belitang Madang Raya students' average concept mastery score in the cognitive area of analyzing (C4) is 35.72, falling into the Moderate category. Of the items in the C5 cognitive domain of evaluating, 34.62 fall into the Moderate category. It seems that none of the 135 pupils fall into either the high or poor concept mastering ability categories.

In the high category, question number 12 with the cognitive domain of analyzing (C4) had the highest average score of 68.01. Including the low group, question number 7 in the cognitive domain of evaluation had the lowest average value, 21.17 (C5).

The moderate category in the cognitive domain of analyzing (C4) and evaluating (C5) student concept mastery shows a deficiency in problem-solving experience using higher-order thinking skills, leading to a deficiency in the student's capacity to analyze and assess a concept.

In order to facilitate students' transition to an independent curriculum and foster critical thinking skills, teachers must carefully plan their time allocation when creating lessons (Fajri et al., 2023). According to Supena et al. (2021), the learning model that is employed also affects the learning outcomes that students attain, including e-learning (Wiyono et al., 2020).

Conclusion

According to studies done on energy and its variations in junior high school students, the average score on student examinations was 36.60, with a subpar performance in the critical thinking abilities area. Then, in the cognitive area of analyzing (C4) and evaluating (C5), the average score on the students' concept mastery test was 35.72 and 34.62 respectively, both falling into the moderate range. Due to students' low literacy regarding energy and its changes, their inexperience working on higher-level thinking questions, the lack of variety in teaching methods, and the infrequent use of experiments, the results demonstrated that students' critical thinking skills were in the poor category and their concept mastery was in the moderate category. This demonstrates the necessity of making significant efforts to raise junior high school pupils' critical thinking abilities. It is crucial for educational policy makers to have preliminary data on the critical thinking abilities of junior high school pupils in order to inform their decision-making process.

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Author Contributions

Conceptualization, Y.C.D., M.Y., and A.F.; methodology, Y.C.D., and M.Y.; validation, M.Y., and A.F.; formal analysis, Y.C.D.; investigation, Y.C.D. and M.Y.; resources, Y.C.D., M.Y., and A.F.; data curation, M.Y.; writing—original draft preparation, Y.C.D. and M.Y.; writing—review and editing, Y.C.D., M.Y., and A.F.; visualization, A.F.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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