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Improvement of Critical Thinking Skills of Junior High School Students on Heat Transfer Material

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Abstract: Critical thinking skills are rarely measured in science learning. This study aims to analyze critical thinking of junior high school students on heat transfer materials. The subjects of this study were class VII students of SMP Negeri 6 Palembang, totaling 32 seventh grade students took written tests as part of the data gathering process, which also included interviews with physics teachers. This research uses a mixed-methods strategy that combines both qualitative and quantitative data. For educational policymakers deciding on next steps, such as the choice of suitable teaching models and instructional materials, aimed at fostering the improvement of students' critical thinking abilities, understanding the profile of students' critical thinking skills serves as a valuable reference. With an average score of 36.12, the results showed that students had comparatively weak critical thinking abilities. Thus, this research can make a significant contribution to the development of effective and innovative learning methods.

Keywords: Critical thinking skills; Heat transfer; Junior high school

Introduction

Natural sciences is learning that stresses direct understanding to foster creativity and competency rather than only exploring theoretical material or concepts that are given by teachers (Aldiyah, 2021; Nurmasyitah et al., 2022). Students are encouraged to participate immediately in analyzing and scientifically observing their surroundings as part of science education. Student orientation as a subject is presently given increased importance in science education. Critical thinking is one of the skills that students need to possess, according to the Department of Defense Education Activity (DoDEA) (Heryani et al., 2023; Ningsih et al., 2018). Performing scientific labor to create a method and product allows students to build a variety of critical thinking and comprehend concepts, which is a unique feature of science learning (Adhelacahya et al., 2023; Hidayati et al., 2021; Solikhin et al., 2021).

According to Depdiknas (2011), science learning that must be done is learning that can educate students for understanding of science and technology, to think critically, logically, and creatively, as well as to think broadly when solving a variety of real problems. As a result, it is anticipated that scientific education will enable students to improve their critical thinking abilities. One of the thinking abilities required by modern learning is the capacity for critical thought. According to Hidayat et al. (2019), critical thinking is the capacity to think deeply in order to gather accurate and (Agnafia, 2019; Pakaya et al., 2023) claims that the capacity for critical thought entails the capacity for intelligent thought and the ability to back up claims with convincing justifications. Critical thinking abilities are necessary for students (Bunt et al., 2020). Students who think critically can solve problems more clearly and effectively (A. Saputra et al., 2020; Wahidin et al., 2020).

During the learning process, students' critical thinking abilities must be developed. Ennis (1993) divides critical thinking indicators into five categories: giving clear explanations, developing fundamental abilities, drawing conclusions, giving more explanations, and formulating strategies and tactics. According to Fisher (2007), there are six key components of critical thinking: identify; interpret; analyze; express viewpoints or engage in argumentation; evaluate; and

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conclude. Various studies have shown that e-modules have been successfully developed through the stages of analysis, design, development, implementation and evaluation, and can be used as Indonesian language teaching materials at various levels of education, such as class XI vocational school (Asrizal et al., 2023). Apart from that, e-modules can also help students who experience difficulties in learning, increase learning motivation, scientific literacy and learning outcomes.

In Indonesia, students still struggle with critical thinking (Zubaidah et al., 2018). According to Basri et al. (2019), only a small percentage of students participated in finding solutions to difficulties that developed while others were inactive when working on group assignments. Additionally, Saputra et al. (2019) found that students' critical thinking abilities were still lacking, as evidenced by the predominating problem symptoms, which included students' difficulties with high-level questions (C4-C6); the persistence of many students' difficulties in connecting concepts and problems; and some students' difficulties in articulating their opinions during discussions. This circumstance can be utilized as evidence of students' analytical and critical thinking skills.

A field research at SMP Negeri 6 Palembang revealed that this institution rarely assesses students' critical thinking abilities. One of the challenges is the lack of instructional materials that enable and prepare students to learn on their own. Teachers continue to employ textbooks, PowerPoint (PPT) presentations of student workbooks, Electronic Student Books (BSE), and other teaching materials. Due to this, they become disinterested and less engaged in their lessons.

According to research by Dani et al. (2019), adopting electronic student books has not improved students' ability to utilize critical thinking since the language is too sophisticated, convoluted, the content is lacking, and the difficulty level of the questions is relatively low. Students struggle to comprehend concepts and refine their critical thinking abilities as a result. Additionally, in order to promote an academic culture and attain high quality, a variety of educational innovations must be appropriately applied (Gunawan et al., 2021).

Choosing learning strategies and media that assist the effectiveness of the learning process is one alternative that needs to be made (Farwati et al., 2021; Listianingsih et al., 2021). A useful intermediary tool for facilitating communication between professors and students is learning media. E-modules and digital flipbooks are popular learning tools that make it simpler to use a mix of print and digital material (Astalini et al., 2019).

Since developing critical thinking abilities involves constant practice and cannot be learned in a single lesson, teaching them to students in schools is difficult (Kurniahtunnisa et al., 2023). To produce graduates who can compete and flourish in the face of future problems, educational institutions must foster critical thinking patterns during the learning process (Cosgun et al., 2021). In order to develop graduates with advanced critical thinking abilities, effective measures must be employed (Ali et al., 2021; Alotaibi, 2013; Ulger, 2018). According to Fikriyatii et al. (2022) this is still not the primary focus in Indonesian educational institutions. It can be seen from some of the latest research results, including those conducted on students, it was found that 33.75% of students have low critical thinking skills. In fact, 36.25% of students are at a very low level of critical thinking (Djufri et al., 2022). If the average student's critical thinking skills are still low, it is necessary to examine how the critical thinking skills of students at the level below.

It is necessary to investigate the profile of high school students' critical thinking abilities in physics courses on heat transfer materials. The results of this study will show how well high school students can use their critical thinking abilities to comprehend, evaluate, and apply the idea of heat transfer materials. The analysis' findings should serve as a guide for educators as they work to design and improve teaching methods, learning environments, and products that might support initiatives aimed at fostering students' capacity for critical thought.

Access to communication and information is now highly swift and widespread because to globalization. Therefore, developing students' critical thinking abilities is crucial for their academic achievement as well as for preparing them to serve as effective future leaders in a society that is becoming more complicated and sustainable (Andayani, 2020). Therefore, this study is highly pertinent and offers insightful information for the advancement of education.

Method

The descriptive methodology utilized in this study's design has as its primary goal describing the phenomena or condition as it actually exists, unaltered (Azmi et al., 2021). According to Creswell (2010), a descriptive technique is a sort of case study that concentrates on one instance by excluding or limiting other examples. A mixed methodology, specifically a qualitative descriptive technique using interviews (Mandagi et al., 2021) and quantitative tests (Nazhifah et al., 2023) was used in this study. It was carried out by South Sumatra Province, specifically SMP Negeri 6 Palembang. As the first group of mobile schools in South Sumatra, SMP Negeri 6 Palembang is thought to have

more expertise adopting an independent curriculum, particularly with regard to heat transfer materials. Students are divided into three groups, low, medium, and high, for the purpose of sampling. Their values in the process of learning physics are referred to as grouping. The study's sample population of 36 students was then chosen. Purposive sampling (Creswell, 2010) is the practice of sampling with a specified objective like this.

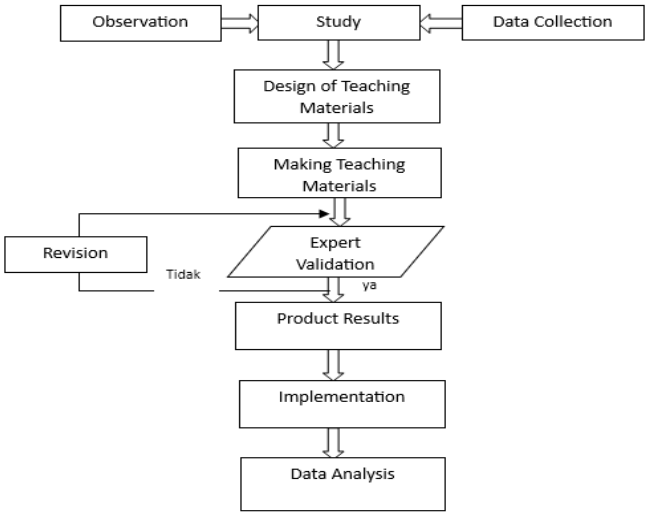

Figure 1. Development research flow

Observation, the observation stage involves identifying a problem or need for instruction, and observing the current situation to determine what needs to be addressed. Study and Data Collection, in this stage, research is conducted to gather information about the problem or need identified in the observation stage. Data is collected through various methods, such as surveys, interviews, and focus groups. Design and Making Teaching Materials. Based on the data collected in the previous stage, instructional materials are designed and created. This may involve developing lesson plans, creating multimedia materials, and designing assessments. Expert Validation, in this stage, the instructional materials are reviewed and validated by subject matter experts to ensure that they are accurate and effective. Product Results. The product results stage involves testing the instructional materials with a small group of learners to determine their effectiveness and make any necessary revisions. Implementation, once the instructional materials have been validated and revised, they are implemented and used for teaching or training. Data Analysis, finally, the data collected during the implementation stage is analyzed to evaluate the effectiveness of the instructional materials and make any necessary improvements. Development procedure Problem-Based Learning-based heat transfer e-module to improve students in junior high school students can be seen in Figure 1.

Interview data was taken directly to physics subject teachers related to learning activities that had been carried out. The questions given to the teacher refer to the interview grid in Table 1.

Table 1. Interview Grid

Aspects	Question items
Learning process	Enthusiasm of students toward physics learning
	The frequency of experimental methods
	Application of varied learning models
Assessment	Types of assessments performed
	Difficulty level of assessment instruments for learners
Learning outcomes	Assess student learning outcomes

The interview's outcomes were qualitatively examined. Interviews with teachers are one of the crucial data points in this study because the findings are fact-based and weren't concocted by the researchers (Mandagi et al., 2021).

Table 2. Distribution of Critical Thinking Skills Test Questions for Heat Transfer Materials

Critical Thinking Skills Indicators	Critical Thinking Sub-Indicators	Heat Transfer Materials	Number of Questions
Provide simple explanations	Students can analyse questions	Form of heat transfer	1
Build basic skills	Students can observe and consider observation reports	Heat transfer sources	1
Inference Skills	Students can create and define value considerations	Development of heat transfer	1
Provide advanced explanations	Students can identify assumptions	Heat transfer power plants	1
Skills in determining strategies and tactics	Students can define an action	Design of heat transfer sources	1

The test questions used in this study were created using Robert Ennis' indicators of critical thinking skills, specifically the capacity to provide straightforward explanations, develop fundamental skills, make deductions, provide more complex explanations, and determine strategies and tactics (Ennis, 1993). There are five essay-like questions that must be answered, and each one requires a justification. Before use, the five questions have been approved by specialists. Test outcomes are evaluated using scoring that is separated

into five categories. If there is no response at all, that receives a score of 0. If students provide incorrect answers and justifications, they receive a score of 1 in the second category. The third category with a score of 2 is if only one of the learners' answers or reasons is correct. The fourth category with a score of 3 is if the answer is correct but the reason is not right. The last category with a score of 4 is if the answers and reasons given are correct. The distribution of the test questions is shown in Table 2.

The data gathering process for the test is computer-based, and the questions are presented in a Google Form platform that is easily accessed via smartphones, laptops, and computers. After that, the researcher examined the students' responses and, with permission from (Muntaha et al., 2021; Rahmadita et al., 2021), divided them into five categories of critical thinking abilities:

Table 3. Classification of Critical Thinking Skills

Range of values	Category
80.00 – 100.00	Excellent
60.00 – 79.99	Good
40.00 – 59.99	Enough
20.00 – 39.99	Less
0.00 -19.99	Very Lacking

Result and Discussion

Categories Students' Critical Thinking Skills

The written test was given to 34 class VII students directly at SMP Negeri 6 Palembang. A total of five essay questions representing five indicators of critical thinking skills are given. Then the researcher analyzes the answers of the learners who have been collected. The results look like in Table 4 and 5.

Table 4. Recapitulation of Students' Critical Thinking Skills Test Results

Categories	Value
Maximum score	48.00
Minimum score	12.71
Average Rating	36.12
Standard Deviation	9.82

Table 5. Recapitulation of Student Value Analysis on Each Category of Critical Thinking Skills

Categories	Value	Number of Students	Percentage (%)
Excellent	80.00-100.00	0	0.00
Good	60.00-79.99	0	0.00
Keep	40.00-59.99	14	37.11
Less	20.00-39.99	16	46.22
Very Lacking	0.00-19.99	4	16.67

According to Table 4, students scored an average of 36.12 points. The maximum was 48.00, and the minimum was 9.71. No one was able to pass this test with a score of 60.00, as shown in Table 5. In other words, nobody in this study can qualify for the good and exceptional category. The majority of the 16 students (46.22%), who received scores ranging from 20.00 to 39.99, fell into the "less" category. The remaining 6 students (16.67%) received scores between 0.00 and 19.99 in the very little category, while 14 students (37.11%) fell into the medium category with scores between 40.00 and 59.99 while the remaining 4 students (16.67%) earned ratings in the very less category ranging from 0.00 to 19.99. Nearly 80% of the participants in this study received answers of 1 or 2. Only a very small percentage of people can obtain a 3. This indicates that the majority of students were unable to provide accurate replies. Alternately, they may be able to provide a valid answer to the question but an incorrect justification.

Average Critical Thinking Skills Scores of Students for Each Indicator

Students' critical thinking skills can be seen from five indicators, namely providing simple explanations, building basic skills, inferring, providing further explanations and organizing strategies and tactics (Ennis, 1993). The average value of students in each of these indicators can be seen through the graph in Figure 2.

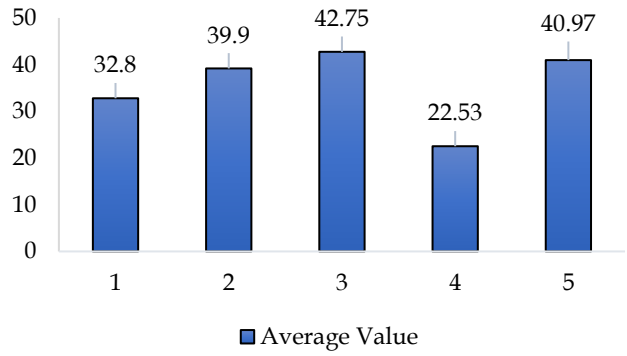

Figure 2. Graph of the average value of each indicator's critical thinking skills

The typical rating of students' critical thinking abilities for each indicator is shown in Figure 2. A simple explanation is provided by the indicator at number 1, basic skills are developed by the indicator at number 2, the indicator concludes at number 3, a further explanation is provided by the indicator at number 4, and strategies and tactics are set at number 5.

The average score of test results for learners for all markers of critical thinking skills is below 59, as can be shown in Figure 2. In more specific terms, students typically scored 32.80 on the indication that provides a

straightforward explanation, 39.19 on the indicator that develops fundamental abilities, and 22.53 on the indicator that provides a more thorough explanation. Figure 2 describes the average score of students' critical thinking skills for each indicator. Number 1 on the vertical axis states that the indicator provides a simple explanation, number 2 states that the indicator builds basic skills, number 3 states that the indicator concludes, number 4 states that the indicator provides a further explanation, and number5 states that the indicator sets strategies and tactics.

Based on Figure 2, it can be seen that the average score of learners' test results for all indicators of critical thinking skills is below 59. In detail, the average score obtained by students for the indicator giving a simple explanation was 32.80, the indicator building basic skills was 39.19, and the indicator giving further explanation was 22.53. All three of them are deficient in critical thinking abilities. With average scores of 42.75 and 40.97, the indicators "inferring" and "organizing strategies and tactics" fall under the heading of having sufficient critical thinking abilities. No one has achieved the good category when looking at the average scores of the five markers of critical thinking abilities.

After the data is processed, it is possible to determine the profile of high school students' critical thinking abilities, particularly with regard to heat transfer materials. In a nutshell, critical thinking abilities are introspective and logical thinking with an emphasis on making decisions with conviction (Fisher, 2000). If a person tries to execute a job accurately, honestly, and clearly, and cares about other people, that person is said to have high critical thinking skills. Before coming to a conclusion, critical thinkers can also clarify, search for, and assess information (Fisher, 2000). Since a person does not naturally possess this critical thinking ability from the moment of birth, it must be regularly practiced in order for it to later flourish in him (Nugroho et al., 2022; Virijai et al., 2022). The accuracy of an educator in choosing learning strategies for the learning process can encourage students to hone their critical thinking skills (Ahmadiah et al., 2023; Wayudi et al., 2020). For that, we need to know in advance how to profile students' critical thinking skills.

Based on quantitative data gathered from tests administered to students at SMP Negeri 6 Palembang, it is determined that students' critical thinking abilities are often below average. Some students even receive a score of 0 for the test question items (Azmi et al., 2021; Hikmah et al., 2023; Marlina et al., 2021) have identified five indicators of critical thinking skills, namely the ability to provide simple explanations, build basic skills, inference skills, skills to provide further explanations, as well as skills to organize strategies and tactics. The outcomes of gathering quantitative data are consistent with those obtained from gathering qualitative data, namely through interviews with physics teacher.

Interview with Physics Teacher

The physics teacher who served as the study's sample said that students' interest in or excitement for this topic was not very strong. One of the indicators is the general lack of activity among students. They still believe that physics is one of the more challenging disciplines because they find it tough to comprehend its concepts. Teachers have used a variety of learning models, but they still frequently use teacher-centered learning as a source of knowledge. Rarely are students given the opportunity to research topics covered independently. Teachers added that it is uncommon for experiments to be done in classrooms.

According to the findings of teacher interviews on evaluation in physics learning, teachers reported that they have evaluated students' knowledge and skills. Teachers give test questions that can be answered orally and in writing to determine how well their students understand the subject matter. While skill evaluation happens when students complete experiments or practica. The majority of the questions on knowledge tests urge test takers to recall, comprehend, and apply previously taught topics.

Teachers occasionally offer questions that invite students to consider the answers. While learners nearly never have the ability to analyze concepts or build or engineer a notion. Based on Bloom's taxonomy, the ability to analyze. According to Bloom's taxonomy, the capacity for analysis, evaluation, and creation belongs to a group of higher-order thinking skills that can enhance students' cognitive abilities on several levels. Aspects of advanced cognitive ability are correlated with critical thinking skill indicators. In order for students to become accustomed to thinking critically, it is necessary to practice answering problems that require a high level of cognitive capacity.

The average scores for the learning outcomes that instructors have gathered are still low. In fact, it happens frequently that the indicators for the targeted learning objectives are not met. Teachers believe that this is closely tied to the previous teaching and learning activities as well as the cognitive ability of the students. For this reason, various ways need to be designed and implemented so that the physics learning process is fun and students are motivated to get used to thinking critically.

Critical Thinking Skills Based on Indicators Provide Simple Explanations

According to Hidayati et al. (2021) and Prabasari et al. (2021) test question number one is a question concerning critical thinking abilities based on the first

sign, namely the ability to provide straightforward explanations with sub-indicators of question analysis.

Students are invited to examine the heat transfer forms at three different positions of items after seeing some illustrations and a brief introduction to the subject. Students received an average grade of 1.3, 1.3, and 1.4 for questions regarding the first, second, and third objects' locations, respectively. The average student score, expressed in grades, is 32.80. The indication gives a brief explanation of the level of critical thinking abilities of students that fall into the "not good" group based on Table 3. These findings are consistent with earlier research that found that learners' analytical skills fall into the low and very low categories (Fatimah et al., 2023; Wayudi et al., 2020). In essence, kids can respond to the questions, but they are unable to adequately define and analyze them. The process of analyzing questions can be challenging for students for a variety of reasons, including their limited literacy skills and interest, their unwillingness to seek out solutions to problems they see, and environmental factors like peer interference that makes it difficult for them to focus on the task at hand (Hidayati et al., 2021; Syafitri et al., 2023).

Critical Thinking Skills Based on Indicators Building Basic Skills

Then, by having them watch and take into account other people's observational reports, students are asked critical thinking skills questions to discover how they may develop their fundamental abilities. The second question asks students to draw conclusions from data that are presented to them in the form of tales and images. The final score is 39.19 with an average student score of 1.5. Even though this score is higher than the one for question 1, it falls into the poor range for critical thinking abilities. According to earlier studies, learners' critical thinking abilities fall into the very poor level for this sub-indicator (Khairunnisa et al., 2020; Neswary et al., 2022). The reason is that they rarely make observations on a problem. The results of interviews with teachers also stated that they rarely conduct experiments. Even though one of the activities in the experiment is observation. Through experimentation, students' observation skills will be honed.

Critical Thinking Skills Based on Indicators Inference Skills

The third test asks you to deduce signs and sub-indicators that determine the importance of a concern. The query is presented as an account of the rise in fuel costs (BBM). In order to support heat transfer policies, students are expected to determine consideration steps. The average score for question number three is 1.8, which, when multiplied by 100, is a score of 42.75. This result is greater than the first and second indicators and even tops the list of the five critical thinking skills indicators that were measured.

According to table 3, learners' critical thinking abilities fall into the medium group for this sub-indicator. That is, some students can already draw conclusions from a problem, especially in determining the value of consideration. These results are in line with the results of the analysis of critical thinking skills of previous High School students (Wayudi et al., 2020). Learners' critical thinking skills for this sub-indicator still need to be improved in order to achieve the good category.

Critical Thinking Skills Based on Indicators Provide Further Explanation

Additional explanations and sub-indicators that indicate assumptions are provided in test question number 4, which is based on skill indicators. As defined by the Indonesian Big Dictionary, assumptions are things that are taken for granted and serve as the foundation for one's thought processes (Firdaus et al., 2023; Muhammad et al., 2023; Nurmasyitah et al., 2023).

In this study, the students' average score on this issue was 0.9, which, when translated, equals 22.53. The lowest average score on the entire test, this score falls into the low group. This indicator adds to the rationale for why it obtained the lowest average when compared to other indicators of critical thinking skills, which is consistent. Serious attention is needed in developing the skills of students in order to be able to meet this indicator well.

Critical Thinking Skills Based on Indicators of Organizing Strategies and Tactics

With the use of sub-indicators of talents, test question number 5's indicators developed plans and tactics and determined an action. The conversion value of the students ' average score, 1.6, is 40.97. When compared to Table 3, it comes in second place behind the third indicator (concluded) and contains the category of moderate critical thinking skills.

Conclusion

According to studies on junior school students' critical thinking abilities related to heat transfer, the results show that these students fall into the category of less proficient thinkers. This shows that there must be considerable efforts made to improve high school students' critical thinking abilities. Firsthand knowledge of the critical thinking skill profile of high school students is essential to serve as a guide for decision-makers in the field of education. Among these factors, it is crucial for teachers to choose the best teaching strategies to support the growth of students' critical

thinking abilities. Given the significance and complexity of the present heat transfer and environmental concerns, increasing student knowledge on heat transfer materials also requires special consideration. Therefore, in order for students to better understand this topic, instructors must increase their knowledge of heat transfer and incorporate heat transfer literacy into learning activities.

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Conflicts of Interest
The authors declare no conflict of interest.

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