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Implementation of the PIMCA Learning Model Assisted by HOTS-based LKPD to Improve Critical Thinking Skills on Temperature and Heat Material

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Abstract
Critical thinking skills are one of the important abilities that students must possess. These skills can be developed through various disciplines, one of which is physics. If we look at its characteristics, the physics topic of temperature and heat has the potential to train students' critical thinking skills by utilizing the knowledge and experiences they already have. However, in reality, students find the topic of temperature and heat difficult and boring. This is due to a lack of student engagement and low understanding of the material. Therefore, the purpose of this study was to ascertain whether or not students' critical thinking abilities might be enhanced by the PIMCA learning model in conjunction with HOTS-based student worksheets (LKPD) on the subject of temperature and heat. With a one-group pretest-posttest design, a quantitative research methodology is applied. The research tool is an essay-based test of critical thinking abilities. Normality tests, hypothesis tests, and N-Gain tests are used in the data analysis of the critical thinking skills test results to glean further specific details about the students' critical thinking abilities. Overall, the study's findings indicate that students' average critical thinking abilities are 0.76, which is classified as high. The areas of basic clarification, basic support, inference, and strategies and tactics demonstrate the high degree of critical thinking abilities. In the meantime, pupils' critical thinking abilities in the category of advanced clarification remain in the medium range.

Keywords: Critical Thinking, LKPD HOTS, PIMCA Learning

1. Introduction

Students in the twenty-first century must possess the necessary life skills to navigate the globalized world. Life skills are essential for solving difficulties and coming to conclusions when they arise. Higher-Order Thinking Skills (HOTS) and problem-solving abilities are connected, claims Karsono (2017). A person's capacity to connect, manipulate, and convert prior information and experiences to make decisions and solve issues in novel settings is known as higher-order thinking skills, or HOTS (Tasrif, 2022).
Brookhart (2010) stated that in defining higher-order thinking skills or HOTS, three terms are used: HOTS as a process of transfer, HOTS as problem-solving, and HOTS as critical thinking. Additionally, Saputra (in Tasrif, 2022) highlights that the primary objective of HOTS is to raise students' critical thinking abilities in handling diverse information, creative thinking in problem

solving by fusing new and old knowledge, and decision making in challenging circumstances. Critical thinking is one of the higher-order cognitive abilities. The goal of HOTS, or critical thinking in education, is to develop pupils who can reason independently and coherently.

A critical thinker, according to Ennis (2011), is an individual who makes decisions about what to believe or do based on reasoning and reflection. According to Hidayah, Salimi, and Susiani (2017), possessing critical thinking skills also means being able to think clearly, reflectively, methodically, and productively—all of which are necessary for making the best decisions and conclusions. Critical thinking abilities are one of the life skills that students need to have in the age of globalization in order to solve issues and discover answers.

One of the many subjects that might help enhance critical thinking abilities is physics. Since physics is a study that examines natural events, it may be helpful in developing critical thinking abilities that are relevant in everyday life (Khaeruddin, Amin, & Jasruddin, 2018). One of the topics in physics is temperature and heat, which is an abstract subject but its applications can be observed in daily life (Ornek et al., in Sundari and Sarkity, 2021). Based on the characteristics of the physics topic of temperature and heat, students can develop critical thinking skills by utilizing their knowledge and experiences.

However, in reality, students find it difficult to think critically and logically because they only memorize physics concepts and formulas without deep understanding (Sundari et al., 2018). As a result, physics is perceived as being challenging and dull, and students will find it difficult to answer issues (Ermayanti & Sulisworo, 2016). This occurs when education remains teacher-centered, depriving students of the chance to participate actively in their education.

The PIMCA learning paradigm is one that encourages students to actively participate in the classroom and develops their critical thinking abilities. Because it can encourage students to think critically, creatively, adapt to technology, and collaborate and communicate effectively, the PIMCA learning model is intended to meet the problems of learning in the age of Industry 4.0 (Poluakan & Katuuk, 2022). Moreover, the PIMCA learning model also has the potential to improve conceptual understanding, problem-solving skills, and student learning outcomes (Kurama & Poluakan, 2023; Sirait et al., 2021). Students' conceptual understanding is very important because it influences their critical thinking skills. This aligns with Istiqamah et al. (2019) who stated that there is a relationship between critical thinking and conceptual understanding. Formative assessment, idea mapping, conceptualization, and presentation are the four phases that make up the PIMCA learning model (Poluakan & Katuuk, 2022).

To make learning more effective, HOTS-based student worksheets (LKPD) are used to train students' critical thinking skills. LKPD is a sheet that contains tasks/problems including instructions that students must follow. LKPD is one way to achieve student learning success through the learning model and help students gain more learning experiences (Ayunda, Lufri, & Alberida, 2023; Tarmizi, Khaldun, & Mursal, 2017). The problems presented in the LKPD will be HOTS-based to train students' critical thinking skills (Krisnahari et al., 2019). This is reinforced by Maqfirah (2020) who showed that critical thinking skills can be trained by working on HOTS-based Physics LKPD and solving problems that fall into the categories of analyzing, evaluating, and creating.

The HOTS-based LKPD will be implemented by students in the third stage, which is the conceptualization stage. This stage is crucial for strengthening the concepts that students have acquired. After that, in the final stage students' will report the results of their HOTS-based LKPD work with a presentation.
There hasn't been much study on combining the PIMCA learning model and HOTS-based LKPD. The researcher intends to examine students' critical thinking abilities in relation to temperature and heat material using the HOTS-based LKPD in conjunction with the PIMCA learning model, based on the description that has been provided. Combining the PIMCA learning model with student worksheets based on the HOTS has not been thoroughly studied (LKPD). The researcher intends to examine students' critical thinking abilities related to temperature and heat in relation to the PIMCA learning model, which is bolstered by HOTS-based LKPD, based on the description given.

2. Method

There were 33 pupils in the 11th grade at the high school in Subang Regency that participated in this study. Convenience sampling is the method of sampling that was employed in this study in an effort to guarantee that the intended sample reflects the interests of the researcher. The mandatory sample is representative and from the same class. In accordance with the research objectives and the class schedule that permitted the research to be done, the sample was also chosen based on the instructor of Physics's considerations at the school. This study employs a one-group pretest-posttest design using a quantitative methodology; Table 1 shows the design in use.

Table 1. One-Group Pretest-Posttest Design Research Design

Pretest	Treatment	Posttest
O_1	X	O_2

Source: Sugiyono (2013)

A critical thinking skills test instrument was used to collect data during the pretest stage (O1). Subsequently, the investigator administered treatment (X), which involved applying the PIMCA learning model in conjunction with HOTS-based LKPD. Posttest data (O2) was then gathered following the administration of the therapy.
The five categories of critical thinking skills that Ennis proposed—basic clarification, basic support, inference, advanced clarification, and strategies and tactics—were followed by the researcher when creating the test instrument for this study. To gauge critical thinking abilities, we employed a test with 17 essay questions. A rubric that we developed based on components of critical thinking abilities was used to evaluate each response to the questions. There was a Likert scale from 1 to 4 in the assessment rubric. This study also made use of HOTS-based LKPD.
The researcher examined the results of the pretest and posttest that the students had taken to ascertain how well their critical thinking abilities were developing. Normality tests, hypothesis tests, and N-Gain tests were the next steps in the investigation. Table 2 provides the following interpretation of N-Gain values for critical thinking abilities.

Table 2. Interpretation of N-Gain Values

N-Gain	Interpretation
$N - Gain \geq 0.70$	High
$0.70 > N - Gain \geq 0.30$	Medium
$N - Gain < 0.30$	Low

Source: Hake (1998)

3. Result and Discussion

The test instrument for this study consists of 17 essay questions that are suitable and meet the requirements for usage. The five types of critical thinking skills that Ennis proposed—basic clarification, basic support, inference, advanced clarification, and strategies and tactics—were the foundation around which we developed the test. Table 3 displays the critical thinking skills test instrument matrix related to the issue of heat and temperature.

Table 3. Critical Thinking Skills Test Instrument Matrix for Temperature and Heat Material

Sub Material	Question Number	Aspects of Critical Thinking				
		EL	BS	I	AC	ST
Temperature and Heat	1a	√				
	1b	√				
	1c	√				
	3			√		
Expansion	2			√		
	4	√				
	5					√
Specific Heat and Heat Capacity	6	√				
	7			√		
Change of State of Matter	8a	√				
	8b	√				
	8c				√	
	8d			√		
Heat Transfer	9		√			
	10	√				
	11					√
	12			√		

Information of Aspect Critical Thinking

EL : Basic Clarification
BS : Basic Support
I : Inference
AC : Advanced Clarification
ST : Strategy and Tactics

In this study, HOTS-based LKPD was also used which has been validated and declared suitable for use. There are two HOTS-based LKPD used. First, the HOTS-based LKPD is Temperature and Heat, Expansion, Specific Heat, Heat Capacity, and Changes of State of Matter which contains experimental activities, observing, reading, and discussing to solve a problem. Second, HOTS-based LKPD on Heat Transfer (Conduction, Convection and Radiation) which contains experimental activities and discussions to solve a problem. This HOTS-based LKPD contains HOTS-based problems to train students' critical thinking skills.

Researchers then analyzed the obtained pretest and posttest data on critical thinking skills by carrying out normality tests and hypothesis tests using IBM SPSS Statistics 26. The results of normality tests and hypothesis tests are presented in Table 4.

Table 4. Analysis of Normality Test and Hypothesis Testing Critical Thinking Skills

Data Type		Pretest	Posttest
Data Source		Critical Thinking Skills Essay Test	
N		33 Student	
Average		33.91	84.00
Normality Test (Shapiro-Wilk)	**Sig.**	0.210	0.168
	Ket.	If value sig. > 0.05 the data is normally distributed	
	Int.	Data was normally distributed	
Hypothesis Test (Paired Sample T Test	**Sig.**	0.000	
	Ket.	If value sig < 0.05 maka H_0 was rejected and H_1 was accepted	
	Int.	There is a significant average difference in the pretest and posttest result	

The Shapiro-Wilk test was used for normality assessment because there were fewer than 50 participants in this study. The normality of the data can be inferred from the normality test results, which showed a value > 0.05. Because the data in this study are normally distributed, we employed the paired sample t-test for hypothesis testing. The hypothesis test results indicated a significant difference between the pretest and posttest mean scores of students' critical thinking abilities, with a significance value < 0.05. The N-Gain test was used to gauge how much students' critical thinking abilities had improved after the results of the normalcy and hypothesis tests showed a significant change.

The N-Gain computation of the pretest and posttest data then shows how well the PIMCA learning model, which is backed by HOTS-based LKPD, has improved students' critical thinking abilities. Table 5 shows the critical thinking skills N-Gain calculation results for 11th grade students at a high school in Subang Regency.

Table 5. The Distribution of Improvement in Students' Critical Thinking Skills

Interpretation	Amount (Student)	Percentage
High	23	69.7
Medium	10	30.3
Low	0	0

According to Table 5, 69.7% of students in the high category and 30.3% of students in the medium category have enhanced their critical thinking abilities. Researchers determine each student's critical thinking abilities by calculating the N-Gain based on test results. In addition to determining the average growth in critical thinking abilities, each aspect's growth in skills will also be computed. Table 6 presents the averages and N-Gain values for each component of critical thinking abilities.

Table 6. N-Gain Critical Thinking Skills

Data Type	Aspects of Critical Thinking					Average
	EL	BS	I	AC	ST	
Pretest	32,42	26,52	38,54	18,94	40,91	
Posttest	87,78	92,42	89,29	59,85	95,83	
N-Gain	0,82	0,90	0,82	0,50	0,93	0,76
Category N-Gain	High	High	High	High	High	High

Table 6 above presents the outcomes of increasing critical thinking abilities in each area: basic support at 0.90 in the high category, advanced clarification at 0.50 in the medium category, elementary clarification and inference at 0.82 in the high category, and strategy and tactics at 0.93 in the high category. This demonstrates that improving critical thinking abilities in all areas is necessary. Four areas of critical thinking abilities fall into the high group, while one area falls into the medium category. Four aspects—basic clarity, basic support, inference, strategy, and tactics—have high categories. In the meantime, advanced clarification—a component of the medium category—improves critical thinking abilities. Overall, critical thinking abilities in the high category improved. The five components of students' critical thinking abilities about temperature and heated materials are explained in the following manner.

Analysis of the Elementary Clarification Aspects

The aspect of elementary clarification is trained when students' fill out the HOTS-based LKPD, namely through experimental activities, observing, reading and discussing to solve a problem. When practicing the aspect of elementary clarification, students must use information they have previously obtained either from experimental results, observing or reading to solve existing problems. Critical thinking skills can also be trained by getting used to asking questions (Sundari et al., 2018). As part of the learning process, students are also trained to ask questions related to the material being discussed, particularly at the Presentation and Assessment Formative stages. Apart from that, when working on LKPD students' carry out discussions to resolve existing problems, namely at the Conceptualization stage.

This factor increased, as evidenced by the high category's 0.82 N-Gain average. This contrasts with studies by Sundari & Sarkity (2021), which found that there was an increase in critical thinking abilities in the moderate group with regard to offering straightforward answers using a scientific method. Thus, we may enhance students' critical thinking abilities in the area of basic clarification by utilizing HOTS-based LKPD and encouraging them to ask questions throughout the learning process.

Analysis of the Basic Support Aspects

The aspects of basic support are trained when students' fill out the HOTS-based LKPD at the Conceptualization stage, namely through experimental activities and answering questions. The aspect of basic support relates to someone assessing the credibility of an observation result (Nugraha & Kirana, 2015). As a result, students will be actively engaged in learning by evaluating the reliability of experimental results and seeking references to solve existing difficulties. This is predicated on how an individual conceives of relating factors in an issue. As a result, at the Idea Mapping stage of the learning process, students are also taught how to create idea maps in order to understand the connections between the topics that will be covered.

This component increased, with a 0.90 N-Gain average in the high group. This is consistent with research from Supriyati et al. (2018), which shows that when active students are included in learning strategies and models, features of fundamental support rise more than other aspects. Thus, students are able to acquire and develop their critical thinking skills when they use the PIMCA learning model in conjunction with HOTS-based LKPD.

Analysis of the Inference Aspects

Students receive instruction in the concept of inference when they complete the HOTS-based LKPD during the Conceptualization stage. This involves problem-solving exercises that involve reading, discussion, and observation. In addition, at the Formative Assessment stage of the PIMCA learning process, students collaborate with the teacher to draw conclusions about the material and HOTS-based LKPD they have studied. An individual requires pertinent information to address the issue at hand in order to reach logical and reasonable judgments (Sundari & Sarkity, 2021).

This component has increased, as evidenced by the high category's 0.82 N-Gain average. This is in contrast to study by Sundari & Sarkity (2021), which claims that when using a scientific approach, the inference element increases the least in comparison to other aspects because there is a dearth of relevant knowledge regarding the issues at hand. Because of this, students who use the PIMCA learning model with the support of HOTS-based LKPD already possess the necessary knowledge to address the issues they encounter. Considering that the application of hots-based LKPD can enhance students' capacity for critical thought (Maqfirah, 2020).

Analysis of the Advanced Clarification Aspects

The aspect of advanced clarification is trained when students' fill out the HOTS-based LKPD at the Conceptualization stage, namely through discussion activities and answering questions. The skill of making further explanations will require students to identify assumptions and then connect them. Where the relationship between these assumptions is used to solve a problem that is being faced (Sundari & Sarkity, 2021).

This aspect showed an increase, with a 0.50 N-Gain average in the medium category. The skill of advanced clarification is the aspect that shows the lowest improvement compared to other aspects. This is a result of students' incomplete understanding of the content being evaluated in this particular area. Thus, before students may develop their critical thinking abilities, they must first grasp the subject matter.

This is consistent with a study by Istiqamah et al. (2019) that found a link between conceptual knowledge and critical thinking. In addition, the skill of advanced clarification will require students to identify assumptions and then connect them. Where the relationship between these assumptions is used to solve a problem (Sundari & Sarkity, 2021). So students' will have difficulty improving critical thinking skills on the aspects of advanced clarification because they lack understanding of the material. The PIMCA learning paradigm can nevertheless help pupils develop their critical thinking abilities, despite its moderate classification. But it's your responsibility as a teacher to make sure that the information is understood by the pupils.

Analysis of the Strategy and Tactic Aspects

The aspects of strategy and tactics are trained when students' fill out the HOTS-based LKPD at the Conceptualization stage, namely through experimental activities and discussions to solve problems. According to Ennis (2011), skills in strategy and tactics are closely related to students' skills in deciding on steps to resolve the problems they face. So that students are trained to choose the best strategy and tactics to solve problems in HOTS-based LKPD.

This aspect showed an increase, with a 0.93 N-Gain average in the high category. Skills in strategy and tactics are the aspect that shows the highest improvement compared to other aspects. Because the questions in this aspect relate to everyday life and guidance questions are given to answer the problem. In learning, giving guiding questions by the teacher has a positive impact before students' decide on a solution to the problems they face (Sundari et al., 2018). Apart from that, it is easier for students' to understand temperature and heat material if the presentation of the concepts is linked to everyday experiences (Haspen & Syafriani, 2022). So that physics learning is linked to everyday experiences, it will simplify for participants to understand the material. If students'' understanding of the material is good, then students' can improve their critical thinking skills.

Based on the students' pretest and posttest findings, it can be observed that there has been a reasonably high rise in the students' critical thinking skills regarding temperature and heat material. Students' critical thinking abilities grow as a result of applying the PIMCA learning model and LKPD, which is developed using the HOTS framework, and developing a solid comprehension of the subject matter. During the first phase, the instructor provides an overview of the subject matter so that the students are familiar with it. In the second phase, the instructor asks the class to develop ideas and think conceptually using the knowledge they have learned. The third stage, the teacher strengthens the concepts possessed by students through working on HOTS-based LKPD. At this stage, students receive information and the teacher, acting as a facilitator, provides instructional assistance. The final stage, the teacher assesses the learning that has been implemented through a presentation of the results of the HOTS-based LKPD work.

Therefore, teachers have an important role in designing appropriate learning to be able to overcome the difficulties experienced by students’ in the concepts of temperature and heat (Sundari & Rimadani, 2020). As a teacher, you must be able to present material that is easy for students to understand, one of which is relating the material to everyday life. If students’ understanding is good, they can practice critical thinking skills. This skills will be trained if students are actively involved in learning and accustomed to working on HOTS problems (Yogantari in Putri et al., 2020; Sundari & Sarkity, 2021).

4. Conclusion

With respect to the previously reported research results, the researchers have concluded that all aspects of critical thinking skills, including advanced clarification in the medium category, can be improved by implementing the PIMCA with the support of HOTS-based LKPD. The elements of fundamental support, fundamental clarification, inference, strategy, and tactics fall within the high category. The area that needed the most work was organizing strategy and tactics; the area that needed the least improvement was giving more details. Overall, the findings indicate that students' critical thinking abilities fall into the high range on average. ln order to develop students' critical thinking abilities through the use of an active learning approach that connects the subject matter to real-world experiences. Apart from that, getting students used to working on HOTS-based problems can train critical thinking skills.

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