JPII 13 (4) (2024) 538-550

Jurnal Pendidikan IPA Indonesia

https://journal.unnes.ac.id/journals/jpii

E-LEARNING-BASED COLLABORATIVE AS AN EFFORT TO REDUCE HIGH SCHOOL STUDENTS' MISCONCEPTIONS OF HEAT

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DOI: 10.15294/jpii.v13i4.13222

Accepted: September 02th, 2024. Approved: November 27th, 2024. Published: November 27th 2024

ABSTRACT

The purpose of this study was to determine the effect of E-learning-based collaborative learning in reducing students' misconceptions about class heat material. This study used a pre-experimental design with a one-group pretest-posttest design. The sampling technique used purposive sampling. The sample used was 300 grade XI high school students. Student misconceptions were analyzed using the CRI (Certainty of Response Index) method. The results showed that student misconceptions decreased by 26.50% from an average of 54.00% before learning to 27.50% after implementing E-learning-based collaborative learning. Based on the results of the hypothesis test, it can be concluded that e-learning-based collaborative learning has proven effective in reducing high school students' misconceptions regarding the concept of heat. The novelty of this study lies in the integration of cooperative learning with an e-learning platform that is specifically designed to reduce misconceptions about the idea of heat at the Senior High School.

Keywords: collaboration, e-learning, heat, misconception

INTRODUCTION

Physics as a branch of science studies and quantitatively analyzes symptoms or processes in nature. Physics is a science knowledge that studies parts of nature and their interactions is in it. Through this interaction, physics helps to reveal and understand the veil of mystery of the universe. In addition, it is a lesson that provides knowledge about nature's universe to practice thinking and reasoning, through the ability reasoning of a person who is continuously trained continues to grow, then the person will increase his thinking power and knowledge (Surawan, 2020). Above all, this is the basis of absolute physics that must be taught to every student. This phenomenon is a serious and necessary problem to get full attention from all parties, both the government, school, community/parents as well as the students themselves.

Many factors cause students to have difficulty understanding concepts. One of the causes is that some physics material concepts are abstract Demircioğlu & Sezgin Selçuk, 2016). Abstract physics concepts are difficult to visualize so students have difficulty examining existing concepts. (Hariyanto, 2020) mentioned that students will be active if they can connect new knowledge with their initial understanding. However, connecting the two in physics learning is not easy. Another reason students have difficulty in learning phy-

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sics concepts is that teachers instill new concepts in students (Ornek et al., 2008) (Muafiah et al., 2021) (Afifah & Retnawati, 2019) (Afifah et al., 2019), but not accompanied by examples of connections to real-life experiences that students have. Mistakes in accepting concepts are called misconceptions. (Sari et al., 2023) Learning the concept of heat in physics is often a challenge for high school students. Many students experience misconceptions or misunderstandings related to basic concepts such as heat transfer, temperature changes, and the relationship between energy and temperature. These misconceptions can hinder students' understanding of more complex physics materials and result in low learning outcomes.

Misconception or wrong concept is a student's understanding of a concept that is not scientifically or theoretically appropriate due to errors in concluding new concepts with concepts that students already have. (Sari & Mufit, 2023) (Batlolona & Jamaludin, 2024)stated that misconception refers to a concept that is not by scientific understanding or understanding accepted by experts in a particular field. Conceptual errors that occur can persist for a long time even though they do not match scientific concepts (Thagard, 2012). In studying physics, students' conceptual understanding is very much needed to get maximum learning outcomes. The concepts embedded in students must be by the actual scientific concepts of physics. Physics concepts that deviate from existing physics concepts can affect students' learning process continuously. If this wrong concept is allowed to continue, students will experience misconceptions. One of the causes of misconceptions is the traditional teaching method that does not actively involve students in the learning process. Students often only become recipients of information without the opportunity to actively construct their understanding through exploration and discussion (Carless, 2022). In today's digital era, the integration of technology in learning offers various opportunities to increase active student participation and reduce the misconceptions they experience.

Another problem after misconceptions were found was the lack of remediation or improvement for students who experienced misconceptions in physics learning. Conceptual errors or misconceptions that occur need remediation. If misconceptions are not remediated, they can interfere with students' understanding of new material concepts. Remediation can be given to students to overcome student misconceptions. Remediation is conducted by integrating learning and solving problems on the concept of temperature and heat to help students who experience misconceptions. Remediation is also needed by other researchers after obtaining information about misconceptions that occur in temperature and heat material. Remediation can be conducted by providing learning models that are adjusted to the characteristics of temperature and heat material.

Remediation can be conducted by providing teaching materials and learning tools that rebuild students' concepts about temperature and heat material. So that student misconceptions do not continue continuously, it is necessary to improve the misconceptions experienced by students so that student conceptions are scientific conceptions. Remedial teaching programs are specific teaching to cure and improve student learning problems. Considering the purpose of remedial teaching, if misconceptions occur, this program can be implemented. However, the teaching method must be adjusted to the nature and purpose of the material being taught (Ekawati & Cari, 2017).

Heat material was chosen because it is widely applied in everyday life, but many students still experience misconceptions. As discussed by (Ratnasari et al., 2017) several materials are identified as often having misconceptions, one of the materials is heat and thermodynamics. Heat and thermodynamics material contains a discussion of the concept of temperature and heat in grade XI physics material. Temperature and heat are physics concepts that are not too difficult to learn, but there are many conceptual errors in this material. The difference in understanding this concept is caused by some students sometimes also having different thoughts and not by the concepts adopted by physicists. This is because students have experienced an event related to the concept of physics before learning is carried out. From this experience, students tend to have theoretical beliefs that cannot be said to be true, so they often cause misunderstandings in a concept or can be called misconceptions (Rizki & Setyarsih, 2022).

The problems that have been described are the reason for researching to reduce misconceptions in heat material with a collaborative learning method based on E-learning. Collaborative learning is learning carried out by two or more people to learn together. One of the goals of collaborative learning is to provide opportunities for students to actively participate in the learning process or what is known as the student center. One solution proposed by this study is the use of internet-based technology to conduct collaborati-

ve learning online. The effectiveness of the collaborative learning model has been applied in research conducted by (Eldiana, 2022) (Nizar, 2021) states that the use of the Collaborative Learning model can improve student learning outcomes as seen from the average student learning outcomes. Research conducted by Susanto states that the average score of learning outcomes taught using the collaborative learning model is categorized as very high and the average score of learning outcomes in the group of students taught using the lecture method is categorized as low. In addition, research conducted by (Anggreni et al., 2019)states that the collaborative learning model affects science learning outcomes. Based on the results of this study, it can be seen that the learning outcomes of students who are taught using the collaborative model are better than students who are taught with conventional learning.

Research by Haryono et al. (2023) stated that misconceptions can be remediated by implementing E-learning-based collaborative learning after comparing the results of diagnostic tests before and after learning about heat material. Research by implementing E-learning-based collaborative learning has also been conducted by (Pratiwi et al., 2022) which concluded that E-learning-based collaborative learning is effective in eliminating misconceptions in students. E-learning-based collaborative learning has emerged as an innovative approach that can be used to help students overcome misconceptions about heat (Mendes & Mendes, 2019). This learning utilizes an e-learning platform that allows active student interaction through discussions, sharing of learning resources, and collaborative activities involving joint problem-solving. (Hamed & Aljanazrah, 2020) Through e-learning, students can learn at their own pace, accessing various interactive media such as videos, simulations, and virtual experiments that can help clarify abstract concepts in physics. (Haryono et al., 2024) stated that there was a significant change in the number of student misconceptions before and after the implementation of E-learning-based collaborative learning (KABEL) about heat in high schools throughout East Java in the era of independent learning. The Mc-Nemar test showed significant results ($\chi 2 = 3.84$, $p < 0.05$) which indicated a significant decrease in misconceptions related to the concept of heat transfer. E-learning-based collaborative learning (KABEL) has proven effective in overcoming misconceptions of high school students throughout East Java in the era of independent learning. The effectiveness value of KABEL is 0.56 which indicates a moderate level of effectiveness. Collaborative learning based on e-learning not only improves conceptual understanding, but also develops students' communication skills, cooperation, and critical thinking skills. With this approach, students have the opportunity to share understanding, clarify wrong concepts, and reinforce correct concepts through discussions with their peers and teachers. The purpose of this study was to determine the effect of E-learning-based collaborative learning in significantly reducing students' misconceptions of heat material for grade XI high school students, as well as to improve student's learning outcomes in physics.

METHODS

The type of research used is a pre-experimental design with the form of a group Pretest-Post test Design with a research instrument in the form of a multiple-choice objective test equipped with CRI (Certainty of Response Index) (Haryono et al, 2024). The purpose of this study was to determine the effect of E-learning-based collaborative learning in reducing student misconceptions about class heat material. The population in this study were grade XI students. Sample selection was carried out using purposive sampling techniques because it was based on certain considerations (Arif et al., 2023) (Jumadi et al., 2023). From this population, were 300 grade XI students who were used as research samples.

One method that can be used to identify misconceptions is the CRI method. The CRI (Certainty of Response Index) method is a tool used to measure how confident respondents are in answering each question given (Firmasari & Nopriana, 2020) (Ibrahim & Sunanto, 2022). The CRI method is used to distinguish students who understand concepts, do not understand concepts, and misconceptions (Nasir et al., 2023). According to Waluyo (2019), CRI is a measure of the level of confidence or certainty of respondents in answering each question (question) given. The CRI method describes students' beliefs in the truth of the alternative answers responded to. The diagnostic test chooses the CRI method because CRI has a scale and is given together with each answer to the question that has been asked.

The data collection technique uses a test method with a research instrument in the form of a multiple-choice objective test equipped with CRI (Certainty of Response Index). CRI is used to identify student misconceptions from the level of student confidence in answering questions on

a scale of 0-5. (Tahmir & Arwadi, 2024)interpret the CRI response scale values in Table 1.

The CRI (Certainty of Response Index) method is a tool used to measure how confident respondents are in answering each question Putri et al., 2023). The CRI method is used to distinguish students who understand the concept, do not understand the concept, and have misconceptions. Table 2 is a table of provisions made by Obiagu et al. (2020) to distinguish between students who understand the concept, do not understand the concept, and have misconceptions both individually and in groups.

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Table 1. CRI Response Scale Values

Scale	Information
0 = Total guessing answer *(Totally Guessed Answer)*	If you answer the question 100% guessed
1 = Almost guessed answer (Almost Guess)	If in answering the question the percentage of guessing elements is between 75%-99%
2 = Not Sure	If in answering the question the percentage of guessing elements is between 50%-74%
3 = Sure	If in answering the question the percentage of guessing elements is between 25%-49%
4 = Almost Certain	If in answering the question the percentage of guessing elements is between 1%-24%
5 = Certain	If in answering the question the percentage of guesswork is zero (0%)

Table 2. Grouping of Concept Understanding Based on the CRI Index

Criteria Answer	Low CRI (< 2.5)	High CRI (> 2.5)
Correct answer	Correct answer and low CRI means not understanding the concept (lucky guess)	Correct answers and high CRI mean good mastery of the concept
Wrong answer	Wrong answer and low CRI means not understanding the concept	Wrong answers and high CRI mean misconceptions

Quantitative analysis is used to determine the percentage of three categories, namely do not understand the concept, understand the concept, and misconception. Students who experience misconceptions from the percentage calculation above are classified based on the level of misconception experienced. The classification of the level of student misconceptions uses the standard deviation equation. The classification divides misconceptions into three levels, namely high misconceptions, moderate misconceptions, and low misconceptions. Interpretation of the level of student misconceptions follows the criteria in Table 3.

Table 3. Interpretation of Misconception Levels

Score	Criteria
s ≥(M+1 SD)	Tall
(M-1 SD) <s <(M+1 SD)	Currently
s ≤(M+1 SD)	low

Hypothesis testing uses a paired sample t-test because the research design uses pretest and posttest data that compare the level of student misconceptions. Hypothesis testing in this study is a two-way test. The criteria for accepting or rejecting the hypothesis at a significance level of 0.05 are if -t table ≤ t count ≤ t table then Ho is accepted and Ha is rejected (Robaeah et al., 2023). Hypothesis test calculations are carried out using the SPSS version 23 application with the following criteria:

H o: μ 1 = μ 2 (sig ≥ 0.05) then H o is accepted.
H a: μ 1 ≠ μ 2 (sig < 0.05) then H a is accepted.

RESULTS AND DISCUSSION

E-learning-based collaborative learning can help explain difficult science concepts so that there are no misconceptions. (Haryono et al., 2023) Defines E-learning-based collaborative learning as a method of explaining concepts or topics through a method, namely by analogizing concepts with events that are easy for students to understand. The analogy is connected to the experiences of events experienced by students in everyday life. This makes it interesting to study the effect of implementing E-learning-based collaborative learning in Physics learning.

Based on Table 4, the hypothesis test is

carried out using a paired sample t-test. Based on the test, it can be concluded that Ho is rejected and Ha is accepted because the significance value obtained is 0.000 (sig <0.05). In addition to being seen from the significance value, it can be seen from the comparison of the t count and t table. The t_{count} value is 7.959 while the t table is 2.045 based on df 29, meaning $-t_{count} < t_{table} < t_{count}$ (-7.959 <2.045 <7.959). The t table value is greater than the $-t_{count}$ and less than the t count, so Ho is rejected and Ha is accepted. So it can be seen that there is an influence of the E-learning-based Collaborative Learning method in reducing student misconceptions about heat material.

The results of the research that has been conducted are in line with the research of Sari, et al (2018) which proves that E-learning-based collaborative learning has a positive effect on remediating student misconceptions of gravity and inertia material. Success occurs because, in E-learning-based collaborative learning, students are given stimulus to build their knowledge with the help of teachers as facilitators. Teachers not only deliver material, but also act as facilitators who help students find their answers, provide direction, and facilitate discussions. Students work together in groups, share ideas, and support each other in the learning process. This collaboration can be done synchronously (for example, via video conference) or asynchronously (for example, via online discussion forums).

E-learning-based collaborative learning provides an opportunity for students to work together to build and discover their knowledge to reduce conceptual errors they experience. The theory of constructivism requires students to construct new knowledge and transform information obtained through the process of adapting new experiences and ideas interacting with something that is already known (Siswanto et al., 2019). Collaborative learning based on E-learning is effective in reducing student misconceptions. One of the reasons why Collaborative Learning based on E-learning is more effective is because this model encourages students to interact and help each other understand the material (Cintia et al., 2018) (Sari et al., 2018). In addition, students who study Collaborative Learning based on E-learning have more opportunities to speak and convey their ideas through e-learning, which can improve their understanding of the material (Kholil & Safianti, 2019).

Table 4. Paired Sample T-Test Results

Percentage of misconceptions before and after	Paired Differences					
	mean	Std deviation	Std error mean	T	df	Sig (2-tailed)
	26,667	18,352	3.351	7,959	29	0.000

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New knowledge in research is built by providing analogous examples in LKS related to real phenomena in everyday life connected with the concepts to be learned (Ardiansah & Zulfiani, 2023) (Sianipar et al., 2023). Through these learning activities, students are guided to understand the concepts being learned. The success of learning activities is greatly influenced by the methods applied because several steps in E-learning-based collaborative learning can support the

formation of concepts according to theory. The process of building student knowledge based on the right concept requires an appropriate learning method. Collaborative learning based on E-learning can be used to understand abstract concepts to be easily understood with analogy bridges related to life around students.

In the research that has been conducted using E-learning-based collaborative learning to reduce student misconceptions on temperature and heat material. Based on the results of the data analysis that has been presented, it is concluded that the application of E-learning-based collaborative learning influences reducing student misconceptions in science learning, especially temperature and heat material. Science learning aims to achieve various competencies, not just mastery of a collection of knowledge in the form of facts, concepts, or principles, but also includes the process of discovery and formation of scientific attitudes (Anggereini et al., 2019).

After statistical tests were conducted, it was stated that there was an influence of E-learning-based Collaborative Learning in reducing student misconceptions on temperature and heat material. By the difference in the percentage level of student misconceptions before and after learning, on average the level of student misconceptions decreased in percentage as seen in Table 5.

Table 5. Average Differences in Students Understanding Concepts (PK), Not Understanding Concepts (TPK), and Misconceptions (M) Before and After Learning

Average Percentage of Understanding Concept, Not Understanding Concept, and Misconceptions		
PK	Before	15.33%
	After	54.83%
TPK	Before	30.67%
	After	17.67%
M	Before	54.00%
	After	27.50%

Based on Table 5, it can be seen that before the treatment, students who understood the concept had an average percentage of 15.33%, while after the implementation of E-learning-based collaborative learning, it increased to 54.83%. Students who did not understand the concept had a percentage before learning of 30.67%, while after learning it decreased to 17.67%. Students' misconceptions before learning reached a percentage of 54.00% but decreased after the implementation of E-learning-based collaborative learning to 27.50%.

The level of student misconceptions seen from the graph in Figure 1 shows that the average percentage before and after the implementation of E-learning-based Collaborative Learning decreased from the percentage before misconception of 54.00% to 27.50%. The percentage decrease in the level of student misconceptions was 26.5%. These results indicate that learning with E-learning-based Collaborative Learning can be used to reduce student misconceptions. The research of (Zorlu & Zorlu, 2022) produced research that learning using analogies has a significant positive effect in eliminating misconceptions. The decrease in misconceptions occurs because each step of learning in E-learning-based collaborative learning supports each other through activities to analogize concepts with students' experiences in everyday life. This makes students understand the concept because it gives a meaningful impression. Ausubel's cognitive learning theory of information processing requires students to learn meaningfully by linking new information to relevant concepts in students' cognitive structures obtained through experience (Abidin et al., 2020).

The results of the diagnosis of misconceptions for each student are classified into 3 levels. The classification is grouped into high, medium, and low misconceptions. The classification of the level of misconceptions before and after the implementation of E-learning-based Collaborative Learning can be seen in Table 6.

Table 6. Classification of Misconception Levels Before and After Learning

Misconception Level	Before		After	
	Number of Students	Percentage	Number of Students	Percentage
High	11	37%	0	0%
Medium	19	63%	20	67%
Low	0	0%	10	33%

Table 6 explains that there are changes in the level of student misconceptions between before and after learning. The high level of misconceptions decreased. The moderate level of misconceptions increased, but only 1 student. The low level of misconceptions increased. Changes in the level of student misconceptions are influenced by the actions taken by teachers by implementing E-learning-based collaborative learning can help change the concept of a physics learning material, especially changing the concept of phy-

sics that is less correct to more correct (Eriyanti et al., 2023; Zulfira et al., 2024). Students learn to build physics concepts with the help of analogy bridges so that the concepts learned are easier to understand in E-learning-based collaborative learning. Teachers form and guide study groups so that students can share information and knowledge that leads to the formation of correct concepts. Learning steps that are designed in such a way can reduce misconceptions through good information processing. By Gagne, a concept that is received by students goes through various stages and processes to be able to reach long-term memory, so that the concepts learned can be remembered (Susanti & Mahaputri, 2022). The learning process by analogizing interrelated concepts will enter the long-term memory scheme so that misconceptions can be avoided.

Table 7. Percentage of Misconceptions for Each Question Item before and after Learning

Question No.	Misconceptions				Indicator	Sub Concept
	Posttest	%	Pretest	%		
1	23	77%	19	63%	1	1
2	20	67%	15	50%		
3	18	60%	9	30%		
4	10	33%	5	17%		
5	17	57%	10	33%	2	2
6	17	57%	2	7%		
7	18	60%	10	33%	3	
8	18	60%	8	27%		
9	12	40%	8	27%	4	
10	17	57%	8	27%		
11	21	70%	7	23%	5	
12	14	47%	7	23%		
13	10	33%	4	13%	6	
14	14	47%	7	23%		
15	21	70%	8	27%	7	
16	12	40%	4	13%		
17	13	43%	6	20%	8	3
18	12	40%	6	20%		
19	11	37%	12	40%	9	
20	26	87%	9	30%		

Based on Table 7, it can be seen that before learning, the percentage of students experiencing the highest misconceptions was in question number 20, which was 87% (as many as 26 students), while students experiencing the lowest misconceptions were in question number 4 and 13, which were 10 students each with a percentage of 33%. After the implementation of E-learning-based Collaborative Learning, it was found that the percentage experiencing the highest misconceptions was in question number 1, which was 63% (as many as 19 students), while the lowest misconceptions were in question number 6, which was 2 students with a percentage of 7%. The highest decrease in misconceptions was in question number 20, which was 57% from 87% to 30%.

The results of the analysis of students' answers to each question on the material of temperature and heat before and after the implementation of E-learning-based collaborative learning can be seen in Table 7. Table 7 shows that each question has students who experience misconceptions. Based on the data presented, it can be seen that 19 questions experienced a decrease in misconceptions and 1 question experienced an increase in misconceptions. The increase in misconceptions occurred in question number 19. In question number 19 before learning 11 students experienced misconceptions, but after learning it increased by 1 to 12 students experiencing misconceptions. Based on the average, students experiencing misconceptions decreased because only 1 question experienced an increase in misconceptions, but the increase was not significant. The

results of the study illustrate that all the concepts tested still leave students who experience misconceptions as in the results of research conducted by (Imaduddin et al., 2023).

Misconceptions that occur after treatment are normal because many experts in the field of education state that preventing misconceptions in students is difficult. (Bayuni et al., 2018; Islamiyah et al., 2022) State that misconceptions are resistant or difficult to change and tend to persist. This statement is reinforced by (Winarni et al., 2022) who explain that the application of learning is very suitable for reducing misconceptions, but cannot eliminate all misconceptions experienced by students. This happens because students have very strong, diverse, and difficult-to-change misconceptions (Yolanda, 2021). Further action activities are needed so that students' logical thinking can change from misconceptions to being by the correct concept.

(Putri & Subekti, 2021) (Fantiani et al., 2023) The level of student misconceptions can be seen from the learning indicators. There are 9 learning indicators, consisting of (1) Distinguishing temperature and heat in everyday life; (2) Providing examples of adaptation as an effort by living things to maintain stable body temperature in everyday life; (3) Applying a non-scaled thermometer scale with a scaled thermometer; (4) Analyzing heat measurements in everyday life; (5) Analyzing the effect of heat on objects in everyday life; (6) Distinguishing types of heat transfer; (7) Analyzing the relationship between temperature and heat with thermoregulation; (8) Concluding the concept of expansion; and (9) Distinguishing expansion in substances. The percentage of students' misconception levels based on indicators can be seen in Table 8.

Table 8. Percentage of Understanding Concepts, Not Understanding Concepts, and Misconceptions for Each Learning Indicator

Indicators	Percentage PK (%)		Percentage of TPK (%)		Percentage M (%)	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
1	20%	48%	21%	12%	59%	40%
2	18%	70%	23%	10%	57%	20%
3	13%	47%	27%	20%	60%	33%
4	4%	52%	43%	21%	52%	27%
5	15%	53%	27%	23%	58%	33%
6	32%	68%	28%	13%	40%	18%
7	12%	60%	33%	20%	55%	20%
8	17%	62%	42%	18%	42%	20%
9	5%	40%	33%	25%	62%	35%

Based on Table 8, it can be seen that before learning, indicator 6 had more students who understood the concept, which was 32%. Indicator 4 had more students who did not understand the concept, which was 43%. Students who experienced the most misconceptions were in indicator 9, which was 62%. After learning by implementing E-learning-based Collaborative Learning, indicator 6 had more students who understood the concept, which was 68%. Indicator 9 had more students who did not understand the concept, which was 25%. Students who experienced the most misconceptions were in indicator 1, which was 40%.

When viewed from the decrease in the level of misconceptions for each learning indicator in Table 9, it can be seen that all learning indicators experienced a decrease in misconceptions. The data that has been presented shows that before learning, the highest percentage of misconceptions for each indicator occurred in indicator 9 about distinguishing expansion in substances. Misconceptions are very high in indicator 9 because students have difficulty distinguishing the expansion of one object from another and do not understand why the expansion of each object is different. After learning, the highest misconception lies in indicator 1 about distinguishing temperature and heat in everyday life. The indicator of distinguishing one concept from another almost similar concept is very difficult to change students' conceptions. Although students already understand that temperature and heat are different, students still do not understand the differences between temperature and heat (Vivi, 2023) (Arifah et al., 2015).

Indicator 1 caused the lowest percentage decrease in misconceptions because it only changed from 59% to 40%. The percentage decrease in indicator 1 was 19%. The highest percentage

decrease was in indicator 2 which decreased from 57% to 20%. The decrease in student misconceptions in indicator 2 was 37%. Indicator 2 explains about giving examples of adaptation as an effort by living things to maintain stable body temperature. Indicator 2 is included in C2, namely the understanding category in Anderson's taxonomy (Syahri & Ahyana, 2021) (Arifah et al., 2015). Indicator 2 includes the lowest cognitive process dimension compared to other indicators, so it experiences a significant decrease in misconceptions. Misconceptions can be reduced in each learning indicator by learning according to the level of student age development. Jean Piaget's cognitive development theory states that physical experiences and environmental manipulation are important for changes in student knowledge development (Clara et al., 2022).

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Table 9. Percentage of Understanding the Concept, Not Understanding the Concept, and Misconceptions for Each Sub-Concept

Sub Concept	PK (%)		TPK (%)		M (%)	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Difference between Temperature & Heat	15	54	29	15	57	31
Heat Transfer	19	61	29	19	51	21
Expansion	11	51	38	22	52	28

Based on Table 9, it can be seen that the sub-concept of temperature and heat differences has the highest misconception, while the sub-concept of heat transfer has the lowest misconception. This happens because students have difficulty distinguishing abstract concepts, namely between temperature and heat in various situations, so even though students can answer one question, they may not be able to answer the other question. In the sub-concept of heat transfer, students are exemplified by the teacher with real activities related to everyday life through experiments and pictures that can illustrate heat transfer in an event, so that misconceptions are lower. In the sub-concept of expansion, there was the lowest decrease in misconceptions, because the percentage decrease was 24% smaller than the others. (Maisura, 2021) This is because students find it

difficult to distinguish the types of materials in expansion and understand the factors that influence expansion and the effects of expansion. Figure 5 explains that in each sub-concept there is a decrease in the level of misconception.

The cause of misconceptions is not only from the type of questions but many factors within the student can be the reason for the wrong concept (Mustofa et al., 2024). (Rahmadani et al., 2023) Mentions several factors that cause misconceptions in students, such as student preconceptions, associative thinking, humanistic thinking, incomplete reasoning, wrong intuition, student cognitive development, student abilities, and student learning interests. The existence of many factors that cause misconceptions makes misconceptions difficult to change with ordinary learning according to the statement (Salsabila et al., 2021). The factors that cause misconceptions are also diverse, so it is very difficult to eliminate all misconceptions that occur in students.

The novelty of this study lies in the integration of E-learning-based collaborative learning that is specifically designed to reduce misconceptions about the concept of heat at the Senior High School. Several aspects that distinguish this study from previous studies include E-learning-based collaborative learning: This study combines the concept of collaborative learning with the use of e-learning technology, which is rarely applied simultaneously in the context of teaching physics concepts. Students not only learn individually, but also collaborate in groups to solve problems, share ideas, and clarify misconceptions about heat together. Use of Interactive Media: This study utilizes interactive media such as simulations, videos, and virtual experiments facilitated through an e-learning platform. This media is designed to visualize abstract concepts about heat that are often difficult to understand with traditional teaching methods. Focus on Misconception Reduction: Many previous studies have focused on improving learning outcomes in general, but this study specifically targets the reduction of misconceptions related to heat, by specifically measuring changes in student understanding before and after the implementation of this learning model. Technology-Based Approach in the Digital Era: In the context of modern learning, this research adapts to the needs of learning in the digital era, where technology is a major element in the educational process. This strengthens the relevance of this research to the current state of education which is increasingly dependent on technology. With the innovation offered, this research contributes significantly to the development of more effective physics learning methods, especially in overcoming misconceptions that are still common problems among high school students.

CONCLUSION

The implementation of E-learning-based collaborative learning can reduce students' misconceptions about temperature and heat material. Hypothesis decision-making can be seen from the significance value of the paired sample t-test of 0.000 which is smaller than 0.05, so that Ha is accepted. The average percentage of misconception levels before learning of 54.00% decreased to 27.50% after the implementation of E-learning-based collaborative learning on heat material. The implementation of E-learning-based collaborative learning can be applied to materials other than heat that cause misconceptions. In addition, the factors that cause misconceptions are diverse, making it very difficult to eliminate all misconceptions that occur in students. Therefore, the selection of E-learning-based collaborative learning must pay attention to cases that are often experienced around students and identify similarities and differences in misconceptions experienced by high school students, so as not to increase student misconceptions. E-learning-based collaborative learning can be developed by combining it with an appropriate learning model that can support reducing student misconceptions. It is hoped that this learning implemented by teachers can support problem-solving in reducing misconceptions that occur in students. Further research could extend the application of e-learning-based collaborative learning to other physics concepts such as force, Newton's laws, or electricity to see its effectiveness in reducing misconceptions across topics. In addition, the use of more sophisticated technologies such as augmented reality (AR) or virtual reality (VR) could be explored to enhance students' learning experiences and deepen the visualization of abstract concepts, especially in physics. Further studies could also examine the long-term impact of this approach on students' conceptual understanding and how the integration of more sophisticated technologies can affect student engagement and learning outcomes across learning contexts.

ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia with

DRTPM and Penelitian Kerjasama Dalam Negeri which has provided funding support and opportunities.

REFERENCES

Abidin, Z., Susilowati, S. M. E., Prasetyo, A. P. B., & Ridlo, S. (2020, June). The profile changes in pedagogical content knowledge of pre-service biology teachers based on the concept maps. In *Journal of Physics: Conference Series* (Vol. 1567, No. 4, p. 042083). IOP Publishing.

Afifah, I. R. N., & Retnawati, H. (2019, October). Is it difficult to teach higher order thinking skills?. In *Journal of Physics: Conference Series* (Vol. 1320, No. 1, p. 012098). IOP Publishing.

Afifah, R. N., Syaodih, E., Suhandi, A., Maftuh, B., Hermita, N., Handayani, H., ... & Samsudin, A. (2019, November). Develop children's science process skills through building activities in center of beam: optical geometry on focus. In *Journal of Physics: Conference Series* (Vol. 1280, No. 5, p. 052016). IOP Publishing.

Anggereini, E., Septiani, M., & Hamidah, A. (2019, October). Application of guided inquiry learning model in biological learning: it's the influence to science process skills and students' scientific knowledge in class XI MIPA high school. In *Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012179). IOP Publishing.

Anggreni, I. D. A. Y. D., Margunayasa, I. G., & Kusmariyatni, N. N. (2019). Pengaruh model pembelajaran kolaboratif ditinjau dari motivasi berprestasi terhadap hasil belajar ipa. *Indonesian Journal Of Educational Research and Review*, *2*(2), 125-136.

Ardiansah, R., & Zulfiani, Z. (2023). Development of interactive e-LKPD based on creative thinking skills on the concept of environmental change. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2), 179–197.

Arif, K., Rusma, O. R., Putri, A. M., & Azzahra, F. (2023). The Effectiveness of the Reading to Learn (R2L) Model on Scientific Literacy Skills on Static Electricity Topic. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6425–6431.

Arifah, N., Padri, I. M., & Feranie, S. (2015). Penerapan Model Learning Cycle 7E Untuk Meningkatkan Konsistensi Ilmiah dan Prestasi Belajar Siswa Pada Materi Suhu dan Kalor. *Prosiding Simposium Nasional Dan Pembelajaran Sains 2015 (SNIPS 2015)*, 457–460.

Batlolona, J. R., & Jamaludin, J. (2024). Students' misconceptions on the concept of sound: a case study about Marinyo, Tanimbar Islands. *Journal of Education and Learning (EduLearn)*, *18*(3), 681–689.

Bayuni, T. C., Sopandi, W., & Sujana, A. (2018). Identification of misconception of primary school teacher education students in changes of matters using a five-tier diagnostic test. *Journal of Physics: Conference Series*, *1013*(1), 12086.

Carless, D. (2022). From teacher transmission of information to student feedback literacy: Activating the learner role in feedback processes. *Active Learning in Higher Education*, *23*(2), 143-153.

Cintia, N. I., Kristin, F., & Anugraheni, I. (2018). Penerapan model pembelajaran discovery learning untuk meningkatkan kemampuan berpikir kreatif dan hasil belajar siswa. *Perspektif ilmu pendidikan*, *32*(1), 67-75.

Clara, E., Agung, I., & Raharjo, S. B. (2022). The role of school curriculum and family resources management (parent participation) in kindergarten children's education. *Journal of Positive Psychology and Wellbeing*, *6*(2), 493–512.

Demircioğlu, S., & Sezgin Selçuk, G. (2016). The effect of the case-based learning method on high school physics students' conceptual understanding of the unit on energy. In *Asia-Pacific Forum on Science Learning & Teaching* (Vol. 17, No. 2).

Ekawati, Y., Sunarno, W., & Cari, C. (2017). Pembelajaran Fisika Melalui Discovery Learning Dengan Metode Eksperimen Dan Demonstrasi Ditinjau Dari Kemampuan Berpikir Kritis Dan Kreativitas Siswa SMK Kelas X Pada Materi Sifat Mekanik Bahan. *Inkuiri: Jurnal Pendidikan IPA*, *6*(3), 17–28.

Eldiana, Y. E. (2022). *Pengaruh Model Pembelajaran Kooperatif Tipe Team Games Tournament Terhadap Keterampilan Sosial Siswa Pada Pembelajaran Tematik Kelas IV SD N 1 Tambahrejo Pasca Pandemi Covid-19* [Undergraduate Thesis, Universitas Lampung].

Eriyanti, I. L., Jumadi, J., Yanarti, Y., & Rosiningtias, W. (2023). Develop e-modules based on Android in Newton's law topic for senior high school. *Jurnal Inovasi Pendidikan IPA*, *9*(1), 62–72.

Fantiani, C., Afgani, M. W., & Astuti, R. T. (2023). Analisis miskonsepsi siswa berbantuan certainty of response index (cri) pada materi pembelajaran laju dan orde reaksi. *Jurnal Inovasi Pendidikan Kimia*, *17*(1), 36–40.

Firmasari, S., & Nopriana, T. (2020). The certainty of Response Index (CRI) and scale of honesty to identify student misconceptions. *Journal of Physics: Conference Series*, *1511*(1), 12114.

Hamed, G., & Aljanazrah, A. (2020). The Effectiveness of Using Virtual Experiments on Students' Learning in the General Physics Lab. *Journal of Information Technology Education: Research* (19), 977-996

Hariyanto. (2020). Kesulitan Pemecahan Masalah Fisika Pada Siswa MAN 3 Jember. *As-Sunniyah*, 58–67.

Haryono, H. E., Marzuqi, I., & Kaniawati, I. (2023). *Development of E-Learning-Based Collaboration (KABEL). 4*(3), 444–456.

Haryono, H. E., Zayyadi, M., Marzuqi, I., & Kaniawati, I. (2024). The Effectiveness of Collaborative E-Learning-Based Learning in Reducing Student Misconceptions on Heat in East Java High

Schools During Merdeka Belajar. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4543-4550.

Ibrahim, M., & Sunanto, S. (2022). Identification and remediation of science misconceptions in elementary school teachers using the P2OC2R model. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *4*(3), 343–350.

Imaduddin, M., Shofa, M. M., Riza, M. F., & Fikri, A. A. (2023). Exploring the pre-service basic science teachers' misconceptions using the six-tier diagnostic test. *International Journal of Evaluation and Research in Education*, *12*(3), 1626-1636.

Islamiyah, K. K., Rahayu, S., & Dasna, I. W. (2022). The effectiveness of remediation learning strategy in reducing misconceptions on chemistry: A systematic review. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *7*(1), 63–77.

Jumadi, J., Sukarelawan, M. I., & Kuswanto, H. (2023). An investigation of item bias in the four-tier diagnostic test using the Rasch model. *International Journal of Evaluation and Research in Education*, *12*(2), 622–629.

Kholil, M., & Safianti, O. (2019). Efektivitas Pembelajaran Penemuan Terbimbing Terhadap Hasil Belajar Matematika Siswa Materi Barisan dan Deret. *Laplace : Jurnal Pendidikan Matematika*, *2*(2), 89–98.

Maisura, B. (2021). *Peningkatan Motivasi Dan Hasil Belajar Peserta Didik Menggunakan Pembelajaran Science-Edutainment Berbantuan Media Flash Card di Mts Ihyaaussunnah* [Undergraduate Thesis, UIN Ar-Raniry Banda Aceh].

Mendes, E., & Mendes, N. (2019). An instructional design for building energy simulation e-learning: an interdisciplinary approach. *Journal of Building Performance Simulation*, *12*(3), 326–342.

Muafiah, E., Afifah, A., Nurohman, D., & Huda, S. (2021). The concept of eco-friendly schools: The application of science education in shaping children's characters to the environment. *Journal of Physics: Conference Series*, *1796*(1), 12063.

Mustofa, H. A., Zain, Z. A., Tsania, H., Azman, M. N. A., Marmoah, S., & Masfuah, S. (2024). Analysis of Student Conceptions based on Cognitive Style on Newton Law Understandings. *Jurnal Pendidikan IPA Indonesia*, *13*(2).

Nasir, M., Sunarno, W., & Rahmawati, F. (2023). The Development of a Two-Tier Diagnostic Test for Student Understanding of Light. *Journal of Turkish Science Education*, *20*(1).

Nizar, A. A. (2021). *Pengaruh Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar Matematika Kelas V SD/MI* [Undergraduate Thesis, UIN Raden Intan Lampung].

Nurleni, N., Junaidi, J., & Asriati, N. (2023). E-Marketing Learning Media Based on Local Wisdom of Sambas Songket Weaving. *Journal of Innovation in Educational and Cultural Research, 4*(2), 337-345.

Obiagu, A. N., Mezieobi, D. I., Aroh, P. N., & Akubue, F. N. (2020). The effect of cooperative concept mapping on misconceptions, knowledge achievement, and transfer of learning in peace education. *The Social Studies*, *111*(1), 18–38.

Ornek, F., Robinson, W. R., & Haugan, M. P. (2008). What Makes Physics Difficult? *International Journal of Environmental and Science Education*, *3*(1), 30–34.

Pratiwi, P., Krismiyati, K., Wahyuadianto, A., & Masrully, M. (2022). Assessing E-learning agility in the Indonesian public sector. *KnE Social Sciences*, 471–490.

Putri, O. D. A., Prastowo, T., & Sanjaya, I. G. M. (2023). Profile of Students' Misconceptions on Substance Pressure Using a Three-tier Diagnostic Test. *IJORER: International Journal of Recent Educational Research*, *4*(1), 1–15.

Putri, R. E., & Subekti, H. (2021). Analisis miskonsepsi menggunakan metode four-tier certainty of response index. *Pensa: E-Jurnal Pendidikan Sains*, *9*(2), 220–226.

Rahmadani, U., Sundari, P. D., Hidayati, H., & Dewi, W. S. (2023). Systematic Review of Misconceptions in Kinematics: Identification, Causes, and Remediation. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 1274–1283.

Ratnasari, D., Sukarmin, S., Suparmi, S., & Aminah, N. S. (2017). Students' conception of heat and temperature toward science process skill. *Journal of Physics: Conference Series*, *895*(1), 12044.

Rizki, C., & Setyarsih, W. (2022). Identifikasi Miskonsepsi Siswa dan Penyebabnya pada Materi Elastisitas Menggunakan Three-Tier Diagnostic Test. *Inovasi Pendidikan Fisika*, *11*(3), 32–43.

Robaeah, W. N., Karman, K., Nasir, T. M., Turwanto, T., & Yulistiawati, L. (2023). The Relationship Between Students' Cognitive Achievement in PAI Subjects and Their Religious Attitudes at SDN 90 Cibiru Panyileukan District Bandung. *Attadib: Journal of Elementary Education*, *7*(2).

Salsabila, N. H., Lu'luilmaknun, U., Triutami, T. W., Hamdani, D., & Apsari, R. A. (2021). Proportion problems: Analyzing common errors. *Journal of Physics: Conference Series*, *1778*(1), 12034.

Sari, D. R., & Mufit, F. (2023). Students Misconceptions and the Causes of Straight Motion Materials Using Six-Tier Multiple Choice. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1987–1995.

Sari, K. W. M., Margunayasa, I. G., & Kusmariyatni, N. N. (2018). Pengaruh Model Pembelajaran Kolaboratif Berbantuan Peta Pikiran Terhadap Hasil Belajar IPA. *International Journal of Elementary Education*, *2*(3), 246-254.

Sari, Y., Qadar, R., & Hakim, A. (2023). Analysis of High School Students' Conceptual Understanding of Physics on Temperature and Heat Concepts. *International Journal of STEM Education for Sustainability*, *3*(1), 212–224.

Sianipar, G., Marconi, M. R., Dewi, R. A. P. K., Natalie, R. Y., & Mardiati, M. (2023). Development of e-lkpd based on socio-scientific issues on learning materials to improve students critical thinking. *Jurnal Scientia*, *12*(04), 240–245.

Siswanto, S., Karimullah, K., Prasetyawati, R., & Nurhayati, N. (2019). Environmental cultured education and its implication on the student's competencies in an Adiwiyata school. *Jurnal Cakrawala Pendidikan*, *38*(3), 552–564.

Surawan. (2020). *Dinamika dalam Belajar*. 194.

Susanti, R., & Mahaputri, D. S. (2022). Bloom's Taxonomy Used By Teacher In Lesson Plans. *ELP (Journal of English Language Pedagogy)*, *7*(2), 1–15.

Syahri, A. A., & Ahyana, N. (2021). Analisis kemampuan berpikir tingkat tinggi menurut teori anderson dan krathwohl. *Jurnal Riset Dan Inovasi Pembelajaran*, *1*(1), 41–52.

Tahmir, S., & Arwadi, F. (2024). Description of Understanding the Concepts of LCM and HCF with the Certainty of Response Index (CRI) Method for Grade VII Students. *Proceeding International Conference on Educational Studies in Mathematics*, *1*(1), 141–148.

Thagard, P. (2012). *The cognitive science of science: Explanation, discovery, and conceptual change*. MIT Press.

Vivi, A. Y. U. K. (2023). *Analisis Model Pembelajaran Pogil dengan Pendekatan Saintifik Terhadap Miskonsepsi pada Materi Suhu dan Kalor Kelas 7 di Mts N 1 Bandar Lampung* [Undergraduate Thesis, UIN Raden Intan Lampung].

Winarni, S., Effendy, E., Budiasih, E., & Wonorahardjo, S. (2022). Constructing a 'concept approval strategy, 'a chemistry learning idea to prevent misconceptions. *Educación Química*, *33*(2), 159–180.

Yolanda, Y. (2021). Penerapan modul penilaian miskonsepsi IPA materi suhu dan kalor terintegrasi CRI (certainly of response index) melalui metode blended learning. *Jurnal Inovasi Penelitian Dan Pembelajaran Fisika*, *2*(2), 74–92.

Zorlu, F., & Zorlu, Y. (2022). The investigation of preservice science teachers' analogical reasoning skills from thinking skills. *Thinking Skills and Creativity*, *43*, 100981.

Zulfira, R., Halim, A., Khaldun, I., Mahzum, E., Nazar, M., & Kasli, E. (2024). The Effect of Interactive Learning Media Using Visual Basic for Application Excel Spreadsheet to Reduce Misconception in Physics Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 28–36.