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Effectiveness of Collaborative E-Learning Model in Reducing High School Students' Misconceptions on Heat

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The urgency of the problem lies in the high level of misconceptions of high school students about heat material even though they have used conventional learning methods, so an e-learning-based collaborative learning model is needed. In reality, the implementation of e-learning is often less than optimal due to limited interaction and direct guidance. The purpose of this study was to determine the level of decrease in misconceptions of high school students about heat material after the implementation of an e-learning-based collaborative learning model. The type of research is a quasi-experimental study with one group pre-test and post-test design. The research population was conducted at SMA A-1 Lamongan. The research sample consisted of two classes, namely class XI-A 32 students and class XI-B 30 students. The data collection technique was quantitatively through written test results (pretest-posttest) accompanied by a belief scale (0-5). The results showed that the decrease in misconceptions of class XI-A was 12.50% and class XI-B was 13.33%. The average percentage decrease in misconceptions was below 50% because there were still students with resistant misconception status after the implementation of an e-learning-based collaborative learning model. Resistant misconceptions occur because the learning style or speed of students constructing concepts takes a long time. Further research is recommended to integrate e-learning-based collaborative learning models with augmented reality technology to improve students' conceptual understanding and reduce misconceptions more significantly.

Keywords: Collaborative; E-Learning; Heat; Misconceptions

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INTRODUCTION

Physics is a branch of natural science that studies the material and its interactions, including several branches, one of which is thermodynamics. Thermodynamics is the study of the physics involved in the transformation of heat energy into other types of energy. The concept of heat is fundamental to thermodynamics. Heat is an important issue that requires understanding from senior high school students. However, some students still do not fully know the concept of heat. Students' poor academic performance in heat studies shows their lack of knowledge. A good understanding of the concept of heat may greatly assist students in overcoming heat-related problems. Temperature, heat, expansion, the effect of heat on things, changes in state, and heat transmission are some key topics that high school students should understand (Haryono & Aini, 2021).

Misconceptions occur when students' knowledge differs from the actual topic. Misconceptions are concepts that vary from those established by experts in the field (Nursyamsi et al., 2018). According to (Suparno, 2005), students' misunderstandings result from their preconceptions, associative thinking, humanistic thinking, incomplete/faulty reasoning, incorrect intuition, cognitive developmental stage, talents, and learning interests. Student misunderstandings represent problems in the educational environment, requiring much effort to eliminate them. Researchers such as (Ekawati Haryono et al., 2020) and (Vinsensia Ade Sugiawati, 2013) have attempted to reduce students' misunderstandings about the topic of heat. These efforts include tactics such as cognitive conflict, the bridge analogy approach (Zayyinah, 2022), and the ARIAS model (Assurance, Relevance, Interest, Assessment, Satisfactions) (Afifah et al., 2018). Misconceptions among students may be successfully reduced by using proper teaching approaches. Teachers are essential as facilitators in helping students through their learning activities, ensuring that ideas are successfully delivered and students are protected against misunderstandings.

One of the alternative learning methods teachers can apply to reduce misunderstandings is collaborative learning models. Collaborative learning is a teaching model that allows students to examine an idea with their classmates. According to (Santoso, 2013), the collaborative learning paradigm can potentially improve students' learning results. This belief is supported by (Dewi et al., 2016) study, which shows that the collaborative learning paradigm may help students develop critical thinking abilities. When students' learning outcomes improve and their critical thinking abilities improve, it indicates that they have a better knowledge of the topics and have fewer misunderstandings.

Collaborative learning models based on e-learning are more efficient and have a positive impact on students. E-learning uses technology to support learning activities, deliver educational content, and potentially enable remote learning. (Sri, 2010) argues that e-learning offers increased flexibility by eliminating the limitations of physical learning spaces and time constraints. Flexible learning schedules are thought to help decrease student misconceptions.

E-learning offers several advantages for students, such as flexible scheduling, easy access to educational resources, enhanced motivation, and overall satisfaction with the learning experience. E-learning is expected to reduce student misconceptions. (Lutfiah et al., 2021) The implementation of the IBSC (Investigation Based Scientific Collaborative) learning model based on e-learning to improve the creative thinking skills of class XI MIPA2 students is categorized as very good. (Haryono et al., 2024) The implementation of collaborative E-learning based learning (KABEL) in senior high schools in East Java during the era merdeka belajar has reduced student misconceptions about heat, both at the individual student level and in connection to specific question indicators. (Zulfira et al., 2024) Interactive learning media based on Visual Basic for Application (VBA) spreadsheet excel has a significant effect in reducing students' misconceptions in learning physics, especially the material of traveling waves. the significance value is smaller than $\alpha = 0.05$, which is 0.000.

Here are some theories related to the study of misconceptions, including:

1. Constructivism Theory

According to (Als Mustofa et al., 2024), constructivism means that students actively construct their own knowledge through experience and reflection. Misconceptions can arise when students incorrectly construct their own understanding of physics concepts.

2. Piaget

According to (Oesterdiekhoff, 2024), Piaget identified the stages of children's cognitive development. Misconceptions can occur because students are at a certain stage that makes it difficult for them to understand more abstract physics concepts.

3. Ausubel's Mental Schemata Model

Ausubel argues that effective learning occurs when students associate new information with the knowledge structure they already have. Misconceptions can arise if the integration of information does not match the existing cognitive structure (Menz et al., 2024).

4. Posner's Concept Theory and Concept Change

Posner and his colleagues highlighted conceptual change as an important part of learning. Misconceptions occur when students do not experience the conceptual changes necessary for proper understanding (Pacaci et al., 2024).

5. Misconception Theory by Driver and Erickson

This theory emphasizes that misconceptions can develop because of differences between the scientific concepts taught and the initial concepts held by students (Uke et al., 2024).

6. Vygotsky's Social Perspective Model

Vygotsky highlighted the importance of social interaction in learning. Misconceptions can arise if students do not receive adequate social support or guidance from teachers and peers (Zahid, 2024).

7. Mental Model by Johnson-Laird

Johnson-Laird proposed that students build mental models of physics concepts. Misconceptions can arise if the mental model that is built is inaccurate or does not match the correct scientific model (Nurjanah et al., 2024).

8. Concept Change Theory by Hewson and Hewson

This theory describes conceptual change as a process that involves confrontation between student concepts and correct scientific concepts. Misconceptions can occur if students do not experience enough confrontation or reflection to improve their understanding (Vančugovienė et al., 2024).

This study aims to examine the effectiveness of a collaborative e-learning-based learning model in reducing high school students' misconceptions on heat topic. The objective of this study is to to examine the effectiveness of a collaborative e-learning-based learning model in reducing high school students' misconceptions on heat topic.

METHOD

The research population was conducted at SMA A-1 in Lamongan. This research was conducted in the odd semester of the academic year 2023/2024. Based on the analysis of pre-tests and post-tests on 20 items of misconceptions about heat. The research sample consists of two Classes: 32 students from Class XI-A and 30 students from Class XI-B. The sampling technique used was simple random sampling, meaning it was chosen randomly without conducting stability and clarity tests of the group's condition before treatment. The research type employed was quasi experimental research, and the research design used was a one-group pre-test design. The study implemented a collaborative e-learning-based learning model in two classes over three sessions, each consisting of two 45-minute periods. This study uses a pretest administered before the treatment and a post-test conducted after the treatment. The research design details can be found in Table 1.

[Table 1 about here.]

The data collection technique in this study involved quantitative data through written tests. Written tests (pretests) were given in both classes (XI-A and XI-B) to identify initial misconceptions. Furthermore, the learning process was carried out using e-learning-based collaborative learning on the heat material. After implementing this learning model, written tests (posttests) were given in both classes (XI-A and XI-B) to identify final misconceptions. The dependent variable is the level of student misconceptions. This study tested the reduction of student misconceptions as the dependent variable, while time, students, and teaching materials were considered as control variables. The research instrument consists of a 20-item test sheet (pretest-posttest) that examines knowledge of temperature, heat, expansion, the effects of heat on objects, changes in state, and heat transfer (Haryono et al., 2023). The test is accompanied by the Certainty of Response Index (CRI) scale.

CRI (Certainty of Response Index) is a standard used to determine the respondent's confidence level (0-5) in answering questions (Saleem, 1999). If the CRI confidence level is lower, the confidence level is also lower, and vice versa. Student misconceptions can be observed from both student answers and their confidence scale. The categorization between understanding the concept, misconceptions, and not understanding the concept individually can be seen in Table 2.

[Table 2 about here.]

In this research, the focus is on the category of students experiencing misconceptions.

The data analysis is conducted by categorizing students who experience misconceptions based on the results of the written tests (pretest-posttest) accompanied by their confidence scale. After categorization, the percentage of student misconceptions is calculated using the formula below:

$$Percentage\ of\ Misconceptions\ = \frac{Number\ of\ Students'\ Misconceptions}{Number\ of\ Students}\ x\ 100\ \%\ \ldots\ldots\ (1)$$

After obtaining the data, it is then analyzed descriptively.

RESULT AND DISCUSSION

[Figure 1 about here.]

Figure 1 shows the percentage of student misconceptions in Class XI-A and Class XI-B of the 11th grade at a specific school in Lamongan. The pretest results for Class XI-A and

Class XI-B show the percentage of initial student misconceptions before implementing the collaborative e-learning-based learning model. The average percentage of initial student misconceptions is 66.04%.

Students typically have preconceptions, which are initial conceptions about concepts (Euwe van den Berg, 1991). Students often have different preconceptions before starting a class. When a student's preconceptions are consistent with the concepts of experts in a particular field, the student does not have misconceptions. However, students may develop misconceptions if the situation is different. To reduce preconceptions that do not align with expert concepts, students can be directly involved in discovering concepts through collaborative e-learning models.

According to (Fahrunissa et al., 2023) there are many misconceptions in the field of physics. (Shofiyah, 2017) Based on diagnostic tests conducted on 4th semester students of Science Education, Muhammadiyah University of Sidoarjo in the Fluids course, it was found that students had difficulty determining the magnitude of hydrostatic pressure because they could not determine the reference point.

Analysis of student misconceptions in heat material includes:

1. Heat is the same as temperature (the higher the temperature, the greater the heat)

Students often assume that heat is the same as temperature due to daily experiences that are misunderstood and the lack of emphasis on conceptual differences during learning (Maryam et al., 2024). For example, when holding a hot object, students feel a high temperature and immediately associate it with a large amount of energy, without understanding that heat is energy that is transferred, while temperature is only a measure of the level of heat of an object. In addition, visual representations in books or experiments that show the temperature increasing during heating also reinforce the view that temperature and heat are always proportional. (Mochsif et al., 2024) The lack of understanding that heat is influenced by mass, type of substance, and temperature changes also makes students simplify this concept by assuming that high temperature means high heat. This indicates the need for learning that emphasizes the fundamental differences between heat and temperature through concrete experiments and cognitive conflict-based discussions.

2. Heat only exists if there is an increase in temperature

Students often assume that heat only exists if there is an increase in temperature because they tend to associate heat with changes in temperature that are immediately visible (Stefanou, 2024). This view is reinforced by everyday experiences, such as when heating water, the temperature increases over time, so students conclude that heat only works when the temperature increases. In addition, the lack of understanding of the concept of phase changes, where heat can be absorbed or released without a change in temperature (for example, when ice melts or water boils), makes students ignore the latent heat process. (Mohammadzadeh et al., 2024) Another factor is the lack of emphasis on the relationship between heat energy and changes in internal energy in learning, so they fail to realize that heat can work without always producing an increase in temperature. To overcome this, concrete experiments and explanations are needed that show how heat works during phase changes or in certain thermodynamic systems.

3. Heat is "lost" when hot and cold objects are mixed

(Brundage et al., 2024) Students often assume that heat is "lost" when hot and cold objects are mixed because they do not understand the concept of conservation of energy, especially Black's principle, which states that the heat released by a hot object is the same as the heat received by a cold object in a closed system. This view often arises because students focus on the final temperature change which becomes uniform, so they think that heat energy is "lost" when high and low temperatures neutralize each other (Yang et al., 2024). In addition, the lack of explicit explanation in learning about how heat moves from hot objects to cold objects until they reach temperature equilibrium can strengthen this misconception. Another factor is the lack of experimental experience that shows the transfer of heat energy in real terms. To overcome this, concrete experiments are needed, such as mixing hot and cold water with temperature measurements, as well as discussions that emphasize that energy is not lost, but only transferred.

4. Heat is not required for phase changes.

Students often assume that heat is not required for phase changes because they only focus on visible physical changes, such as ice melting or water boiling, without realizing that energy is needed to break or change the bonds between particles in a substance (Souisa et al., 2024). In addition, a lack of understanding of the concept of latent heat, which works without affecting the temperature during a phase change, leads students to assume that if the temperature remains constant, then no heat is involved. (Alasadi & Baiz, 2024) Learning that does not explicitly explain or demonstrate how energy is used for phase change processes also reinforces this misconception. Everyday experiences, such as ice melting at room temperature without direct heating, can also be misinterpreted as evidence that heat is not required. (Wu et al., 2024) To overcome this, experiments are needed that demonstrate the relationship between heat and phase changes, such as measuring the time and energy required to melt ice or boil water without changing temperature.

The concepts taught included temperature, heat, expansion, the impact of heat on objects, changes in state, and heat transfer (Brundage et al., 2024). The posttest results for Class XI-A and Class XI-B represent the final percentage of student misconceptions after implementing the collaborative e-learning-based learning model. The average percentage of student misconceptions at the end of the course is 53.13%. This study shows that collaborative e-learning, which focuses on group learning and collaborative concept exploration, generates significant student interest. Students' high interest can positively impact learning outcomes, showing an excellent understanding of the concepts. (Setiawan, 2015) supports the idea that group learning improves students' cognitive learning outcomes and their motivation to learn. In each session, e-learning content about the current lesson was presented. E-learning facilitates students' comprehension of concepts due to its convenient accessibility. (Husnussaadah, 2021) argues that e-learning allows students to engage in various learning activities beyond passive listening, such as observing, performing, demonstrating, and visualizing teaching materials. Interactive and visual elements engage students and enhance their understanding of the concepts being taught.

The collaborative e-learning-based learning model was implemented in Class XI-A and Class XI-B. However, the reduction in misconceptions observed in the posttests for both classes was below 50%. The posttest results show some students still have misconceptions. Some students chose the right answers but gave incorrect explanations and were very confident in their answers. Students showing such behaviors are classified as resistant misconceptions. These students held misconceptions before and after using the collaborative e-learning model. Students with persistent misconceptions may need additional time to fully understand the material. Misconceptions can be resistant because of differences in learning styles or the varying speeds at which students understand the material presented by the teacher (Aryungga, 2014). Collaborative e-learning-based learning models have the potential to reduce misconceptions, as evidenced by the small percentage reduction in this study. However, this study has weaknesses such as limited research scope that only covers certain samples, the need for adequate technological infrastructure, differences in student abilities in using technology, and a focus on results that tend to be short-term without longitudinal evaluation. However, this study provides fundamental implications for the world of education, such as the importance of designing interactive collaborative learning, improving teacher competence in utilizing technology, ensuring the availability of digital infrastructure, and conducting continuous misconception evaluations to ensure long-term learning effectiveness. These findings emphasize the importance of collaborative learning to improve students' conceptual understanding more deeply.

CONCLUSION

According to the study results, using the collaborative e-learning-based learning approach reduces high school students' misunderstandings on heat topic. However, despite this effectiveness, there are still students who maintain the status of resistant misconceptions. This study can be extended by incorporating a larger set of test items, aiming to better assist students who exhibit resistant misconceptions. The advantage of collaborative e-learning lies in its ability to facilitate interaction between students, allowing them to discuss and provide feedback to each other, which can clarify understanding and overcome misconceptions. By utilizing digital platforms, students can also access various learning resources independently, deepening their understanding of difficult concepts.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

LIST OF TABLES

TABLE 1 / Show a One Group Pre-Test and Post-Test Design

Pre test	**Treatment**	**Post test**
T1	X	T2

(Arikunto, 2016)

T1 : Initial test (pre-test) conducted before the treatment
X : Treatment using a collaborative e-learning model
T2 : Final test (post-test) conducted after the treatment

TABLE 2 / Categorization of Individual Understanding, Misconceptions, and Lack of Conceptual Understanding

Category	Low CRI (<2,5)	High CRI (>2,5)
Correct answer	Correct answer, low CRI value means a lack of conceptual understanding	Correct answer, high CRI value means understanding the concept
Incorrect answer	Incorrect answer, low CRI value means a lack of conceptual understanding	Incorrect answer, high CRI value means experiencing a misconception

(Saleem Hasan, 1999)

LIST OF FIGURES

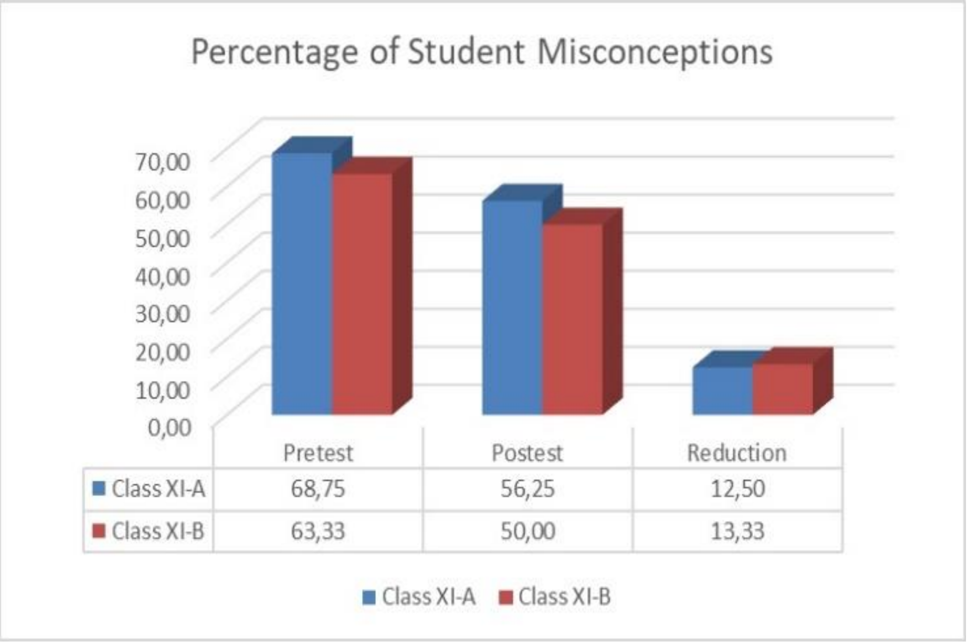

FIGURE 1 / Percentage of Student Misconseptions on the Heat Topic