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Correcting Middle School Students' Misunderstandings Using the CLIS Model on Temperature, Heat, and Expansion Material

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Abstract: Students' misconceptions in science learning, particularly on temperature, heat, and expansion, are still frequently found in junior high school and have the potential to influence the development of an accurate understanding of scientific concepts. This situation indicates the need for the implementation of a learning model oriented towards conceptual change. Therefore, this study aims to analyze the effectiveness of the Children's Learning in Science (CLIS) model in remediating misconceptions among seventh-grade students at the UNP Laboratory Development School. This study was a pre-experimental study with a one-group pretest-posttest design involving 25 students. Data were collected through a diagnostic test to identify misconceptions, observation sheets on the implementation of the learning model, and student response questionnaires. Data were analyzed using the Decrease of Quantitative Misconception (DQM) index and the McNemar test using SPSS. The results showed that the average percentage of student misconceptions decreased from 23% in the pretest to 10% in the posttest, while the percentage of students who understood the concepts increased from 14% to 54%. The CLIS model was implemented well, with an average learning model implementation score of 73%. The DQM analysis showed the effectiveness of remediation in the moderate category, with an average score of 59%. The McNemar test obtained an Asymp.Sig. value of 0.000 with a significance level of α = 0.05, indicating a significant difference between student conceptions before and after the learning process. Furthermore, the questionnaire results showed that 71% of students responded well. Thus, the CLIS model was effective in producing significant changes in conceptions and received positive responses, thus having implications for improving the quality of science learning.

Keywords: CLIS model; Misconceptions; Remediation; Science learning; Temperature and heat

Introduction

Education plays a strategic role in improving the quality of human resources through the continuous development of knowledge, skills, and values. Education is a conscious effort designed to transmit cultural values and shape individual personalities to adapt to societal developments (Lathifah et al., 2024; Munandar et al., 2022). In the national education system, the curriculum is a crucial component that guides the learning process so that educational goals can be effectively achieved (Rahayu et al., 2023). One subject that significantly contributes to developing students' scientific thinking skills is Natural Science (IPA). Science learning systematically and empirically examines various natural phenomena and emphasizes the scientific process in understanding scientific concepts (Sirajudin et al., 2022).

Science learning aims not only to transfer knowledge but also to develop logical, critical, and scientific thinking skills through in-depth conceptual understanding (Lestari et al., 2024). Conceptual understanding is a student's ability to explain, interpret, and connect various scientific concepts meaningfully (Suwarto, 2013). Students with good conceptual understanding tend to be able to explain natural

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phenomena scientifically and apply these concepts in various everyday life situations (Harefa et al., 2022; Novanto et al., 2023). Therefore, the success of science learning is largely determined by the extent to which students are able to correctly understand scientific concepts.

However, in science learning practices, conceptual errors known as misconceptions are still frequently encountered. Misconceptions are conceptual understandings that are inconsistent with scientific concepts accepted by experts (Maison et al., 2020; Suparno, 2013). These conceptual errors can arise from various factors, such as incorrect prior knowledge, inaccurate intuition, incomplete reasoning, or learning processes that do not provide opportunities for students to actively construct their understanding (Mukhlisa, 2021; Suprapto, 2020).

Misconceptions that are not promptly addressed can persist in students' cognitive structures and hinder further learning. Students tend to maintain their initial understanding even when it does not align with scientific concepts (Utami, 2019). This condition makes it difficult for students to grasp advanced concepts because incorrect prior knowledge becomes the foundation for building new knowledge. Therefore, identifying and correcting misconceptions is a crucial step in improving the quality of science learning.

Theoretically, efforts to address misconceptions are closely related to constructivism theory, which states that knowledge is actively constructed by individuals through the interaction between new experiences and prior knowledge (Suparno, 2013). From a constructivist perspective, the learning process involves not only receiving information but also reconstructing knowledge through assimilation and accommodation mechanisms (D. Fitria et al., 2021). This process enables conceptual change, namely the transformation of erroneous initial understandings into more accurate scientific concepts through meaningful learning experiences (Aris, 2022).

Theoretically, conceptual change in science learning does not occur instantly, but rather through a process of cognitive restructuring triggered by conflicts between prior knowledge and scientific concepts. Recent research shows that misconceptions tend to be resistant because they are formed from everyday experiences that are internalized in students' cognitive structures, thus requiring systematic and continuous learning interventions (Aleknaviciute et al., 2023; Amiruddin et al., 2024). Furthermore, the success of conceptual change is strongly influenced by the learning ability to present meaningful cognitive conflicts and provide students with opportunities to evaluate and reconstruct their understanding (Şensoy et al., 2025; Skoumios et al., 2006). In this context, students' prior knowledge is a key factor in determining the direction of conceptual change, so learning strategies must be able to accommodate and direct this prior understanding toward correct scientific concepts (Heller et al., 2012). Therefore, a learning approach is needed that is not only oriented towards conveying information but also able to facilitate the process of reflection, discussion, and active knowledge reconstruction.

Learning that facilitates conceptual change generally provides students with opportunities to explore their initial ideas, test their consistency with empirical evidence, and reconstruct their understanding through discussion and reflection. Social interaction also plays a crucial role in the learning process, as the exchange of ideas between students can help correct conceptual misunderstandings (Ocak et al., 2021). Therefore, a learning model capable of systematically facilitating conceptual change is needed.

One learning model developed based on constructivist principles is the Children Learning in Science (CLIS) model. The CLIS model emphasizes the process of expressing students' initial ideas, testing concepts through learning experiences, and reconstructing conceptual understanding through discussion and reflection (Rustaman et al., 2021). This model consists of several stages: orientation, idea generation, idea restructuring, idea application, and idea consolidation (Sele et al., 2021). Through these stages, students are given the opportunity to evaluate the fit between their initial concepts and scientific concepts, thus allowing for cognitive conflict that drives conceptual change (Hanum et al., 2023).

In addition to implementing an appropriate learning model, identifying misconceptions also requires a diagnostic instrument capable of revealing students' levels of understanding in greater depth. One widely used instrument is the Four-Level Test developed by Caleon et al. (2010). This instrument consists of four levels of questions: conceptual answer, confidence in the answer, reason for the answer, and confidence in the reason given. Through the combination of these four levels, the Four-Level Test is able to distinguish between students who truly understand a concept, those who do not, or those who experience misunderstandings (Gurel et al., 2015).

Various previous studies have shown that implementing a constructivism-based learning model can help correct student misconceptions. Research by Solehah et al. (2024) showed that implementing a CLIS model significantly reduced students' misconceptions in science learning. Another study by Sismawati et al. (2023) found that implementing a CLIS model combined with animation reduced misconceptions about the concept of heat transfer. Research by Fitria (2022) and Muliyadi (2023) also showed that a CLIS model supported by PhET simulations was effective in correcting students' misconceptions about the concept of fluid pressure.

Although various studies have demonstrated the effectiveness of CLIS models in reducing misconceptions on several physics concepts, research on the application of CLIS models to correct misconceptions on the topics of temperature, heat, and expansion is still relatively limited. Furthermore, research integrating the use of the Four-Level Test diagnostic instrument to identify and evaluate changes in misconceptions after the application of CLIS models is still limited. This is despite the fact that temperature, heat, and expansion are fundamental concepts in physics that often lead to misconceptions among students.

This study aims to analyze the effectiveness of the application of the Children Learning in Science (CLIS) model in improving students' misconceptions on the topic of temperature, heat, and expansion at SMP Pembangunan Laboratorium UNP using the Four-Level Test diagnostic instrument. This study is expected to provide empirical contributions to the development of learning strategies based on conceptual change in science learning and become a reference for educators in designing more effective learning to systematically identify and improve students' misconceptions.

Method

This study employed a quantitative approach with a pre-experimental approach using a single-group pretest–posttest design. This design was chosen because the study aimed to determine changes in students' conceptions before and after the implementation of the Children Learning in Science (CLIS) learning model as a misconception remediation effort. In this design, one group of subjects was given a pretest to identify the initial conditions of misconceptions, then given treatment in the form of learning using the CLIS model, and concluded with a final test (posttest) to observe the changes in conceptions that occurred. This design allows researchers to compare conditions before and after treatment so that the effectiveness of the learning intervention can be directly analyzed (Sugiyono, 2014).

Figure 1. Stages of research

This research design can be expressed as O_1 X O_2, where O_1 is the pretest, X is the treatment in the form of implementing the CLIS model, and O_2 is the posttest.

This research was conducted at the Laboratory Development Junior High School, Padang State University (UNP) during the odd semester of the 2025/2026 academic year. The research location was selected based on the school's curriculum implementation, which supports concept-based learning and provides researchers with access for systematic data collection. This research focused on science teaching about temperature, heat, and expansion, topics frequently associated with student misconceptions.

The population in this study was all seventh-grade students of SMP Pembangunan Laboratorium UNP, consisting of six study groups. The research sample was selected using the intact group technique, namely sampling based on naturally formed class groups. The sample selection was carried out based on the recommendations of science subject teachers, taking into account the suitability of the material that has been studied by the students. Based on these considerations, class VII D was selected as the research sample with a total of 25 students who have studied the material on temperature, heat, and expansion.

The research instruments used included a Four-Tier Test diagnostic test, an observation sheet for the implementation of the learning model, and a student response questionnaire. The Four-Tier Test diagnostic test was used to identify students' misconceptions about the topics of temperature, heat, and expansion. This instrument consists of four levels of questions: conceptual answer, level of confidence in the answer, reason for the answer, and level of confidence in the reason given. This structure allows researchers to distinguish between students who understand the concept, do not understand the concept, or experience misunderstandings (Caleon et al., 2010; Gurel et al., 2015). The observation sheet was used to assess the implementation of the CLIS model syntax during the learning process, while the student response questionnaire was used to obtain information about students' responses to the learning that had been implemented.

The observation instrument and student response questionnaire were developed based on the CLIS model syntax and research objectives. The construct validity of the instrument was tested through expert assessment by expert validators to ensure the alignment of the indicators with the theoretical constructs being measured, the clarity of the wording, and the relevance of the statement items to student characteristics. The instrument was assessed using a Likert scale, which allows for systematic measurement of the level of learning implementation and student responses (Sugiyono, 2014). The validation results indicated that the research instrument was in the good to excellent category, making it suitable for use in research data collection.

Data collection was conducted through several stages. In the initial stage, students were given a pretest using the Four-Level Test to identify their initial misconception profiles. Next, the learning process was implemented using the Children Learning in Science (CLIS) model, which includes the stages of orientation, idea generation, idea restructuring, idea application, and idea consolidation. Throughout the learning process, the implementation of the CLIS model was observed using an observation sheet. After the treatment was completed, students were given a posttest using the same instrument to observe changes in conceptions after the learning. In addition, a student response questionnaire was administered to determine students' perceptions of the learning that had been implemented.

Data analysis was conducted using quantitative descriptive analysis techniques and inferential statistical analysis. Data from observations of the implementation of the learning model and student response questionnaires were analyzed using a Likert scale which was then converted into percentages to determine the interpretation categories of the results (Arikunto, 2019; Dalifa et al., 2025). The profile of student misconceptions was analyzed based on the conception categories generated from the Four-Level Test, namely understanding the concept, not understanding the concept, misconceptions, false positives, and false negatives, by calculating the percentage of each category on each concept indicator.

To determine changes in misconception levels, analysis was conducted using the Decreasing Quantity of Misconception (DQM) approach, which calculates the percentage decrease in misconceptions between the pretest and posttest (Mufit et al., 2019; Sua et al., 2022). The DQM value is used to determine the level of effectiveness of misconception remediation with high, medium, or low categories (Kurniawan et al., 2016). In addition, changes in students' conceptions before and after treatment were also analyzed using the McNemar test, which is used to test differences in paired categorical data between the pretest and posttest. The McNemar test calculation was carried out with Yates' continuity correction to obtain a more conservative estimate of the chi-square value (Sua et al., 2022). Data processing was carried out using SPSS software and Microsoft Excel to obtain accurate and systematic analysis results.

Result and Discussion

Implementation of the CLIS Learning Model

Observations showed that the implementation of the Children's Learning in Science (CLIS) model in science learning in grade VII of SMP Pembangunan Laboratorium UNP was generally well-executed. The average percentage of teacher activity implementation during learning reached 73%, categorized as good, while student activity reached 62%, categorized as good. This is presented in Table 1.

Table 1. Percentage of Implementation of Teacher Activity Learning Model

Syntax	Percentage (%)	Category
Orientation	75%	Good
emergence of ideas	72%	Good
rephrasing of ideas	80%	Very good
implementation of ideas	81%	Very good
consolidation of ideas	56%	Good
average	73%	Good

In teacher activities, the highest percentages were found at the idea implementation stage (81%) and the idea restructuring stage (80%). Meanwhile, the lowest percentage was found at the idea consolidation stage (56%).

Table 2. Percentage of Implementation of Student Activity Learning Model

Syntax	Percentage (%)	Category
Orientation	62%	Good
emergence of ideas	62%	Good
rephrasing of ideas	59%	Good
implementation of ideas	81%	Very good
consolidation of ideas	47%	Not good
average	62%	Good

A similar thing was also found in student activities, where the idea implementation stage had the highest percentage of 81%, while the idea consolidation stage had the lowest percentage of 47%.

These results indicate that the CLIS model syntax can generally be applied in classroom learning. However, the low percentage of students participating in the idea consolidation stage indicates that reflection and concept reinforcement activities have not been fully optimized. In constructivist-based learning, the reflection and concept consolidation stages play a crucial role in helping students reconstruct scientific understanding more consistently (Rahmawati et al., 2023).

Furthermore, the differences between teacher and student activities indicate that although teachers have implemented learning in accordance with CLIS syntax, active student engagement still needs to be improved. This is in line with Putri et al. (2022), who stated that the success of constructivist learning is greatly influenced by the level of active student participation in constructing their own knowledge.

Student Concept Understanding Profile

The results of the pretest analysis showed that students' conceptual understanding of temperature, heat, and expansion was still relatively low. The percentage of students who did not understand the concepts was 47%, 23% had misconceptions, and only 14% of students fell into the conceptual understanding category. This can be seen in Graph 1.

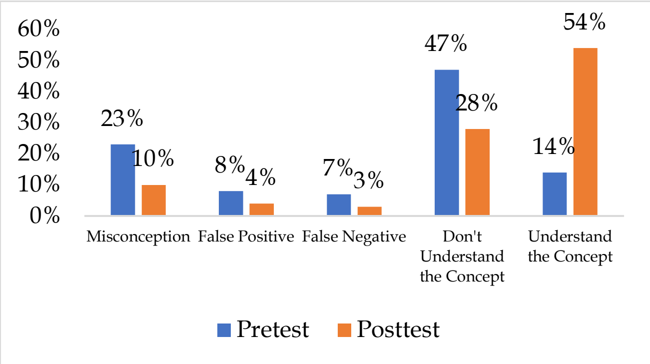

Figure 2. Student concept understanding profile

After implementing the CLIS model, posttest results showed an increase in students' conceptual understanding. The percentage of students with conceptual understanding increased to 54%, while the percentage of students with misconceptions decreased to 10%, and the percentage of students with conceptual incomprehension decreased to 28%.

This increase in conceptual understanding indicates that the CLIS model is able to facilitate conceptual change in students. Through the stages of idea generation, discussion, and conceptual reconstruction, students are given the opportunity to express their initial understanding and then compare it with scientific concepts.

This process aligns with the theory of conceptual change, which states that conceptual change occurs when students are confronted with discrepancies between prior knowledge and scientific explanations (Sele et al., 2021). These results also align with research by Sari et al. (2019), which showed that the CLIS model is effective in improving conceptual understanding and reducing misconceptions in science learning.

Percentage of Students Experiencing Misconceptions

Further analysis showed a decrease in the percentage of misconceptions across nearly all concept indicators. The average percentage of misconceptions decreased from 24% in the pretest to 10% in the posttest, a decrease of 13%, as seen in Table 3.

Table 3. Recapitulation of the Percentage of Students Who Experienced Misunderstandings

Indicator	Pretest	Posttest	Reduction of misconceptions
Explaining the concept of temperature	50%	22%	28%
Explaining temperature phenomena in everyday life	21%	7%	15%
Applying temperature scale measurements with various scales	4%	0%	4%
Explain the concept of heat	14%	6%	8%
Explain the relationship between heat and temperature changes	24%	12%	12%
Determine the factors that influence heat	18%	6%	12%
Determine the various types of heat transfer	16%	8%	8%
Distinguish between heat transfer through convection, conduction, and radiation	12%	8%	4%
Explaining the phenomenon of heat in everyday life	36%	16%	20%
Explaining the coefficients of expansion of length, area, and volume	34%	16%	18%
Explain the properties of expansion caused by temperature and heat	29%	13%	16%
Average	24%	10%	13%

The reduction in misconceptions obtained in this study indicates that the application of the Children Learning in Science (CLIS) model is effective in facilitating the reconstruction of students' understanding of temperature, heat, and expansion. Misconceptions in this material generally stem from generalizations of everyday experiences that do not fully align with scientific concepts (Rahmawati et al., 2023). Through the stages of orientation, idea generation, restructuring, and conceptual consolidation, CLIS provides space for students to systematically test and revise their initial understanding, thus making the process of conceptual change more meaningful than expository learning (Lestari et al., 2024).

A comparison of pretest and posttest results revealed consistent conceptual shifts across nearly all indicators, suggesting that these changes were the result of the learning intervention, not chance. The pretest–posttest design allows for the identification of measurable conceptual changes by mapping students' initial and final states of understanding (Utami, 2019). These findings confirm that constructivist-based learning, which emphasizes cognitive conflict and conceptual clarification, can significantly reduce misunderstandings.

The reduction in misconceptions was not limited to a single indicator, but rather spread across the various concepts tested. This suggests that learning with the CLIS model not only corrects specific errors but also helps students understand the relationships between concepts in a more integrated manner. Students' active involvement in discussions, experiments, and conceptual reflection supports the formation of more stable and scientific knowledge structures, as reported in previous research (Kurniawan et al., 2016). Overall, these findings emphasize that a constructivist approach through the CLIS model is a relevant and empirical strategy for addressing misconceptions in science learning.

Analysis of Changes in Students' Conceptions Based on the Decrease in the Number of Misconceptions (DQM)

The DQM analysis results showed an average value of 59%, which is in the moderate category. The highest DQM value was found in the third concept indicator, with a value of 100%, while the lowest value was found in the eighth concept indicator, with a value of 33%. This can be seen in Table 4.

Table 4. Recapitulation of the Effectiveness of Misunderstanding Correction Based on DQM

Indicator	DQM (%)	Category
Explaining the concept of temperature	56%	Medium
Explaining temperature phenomena in everyday life	69%	Medium
Applying temperature scale measurements with various scales	100%	High
Explain the concept of heat	57%	Medium
Explain the relationship between heat and temperature changes	50%	Medium
Determine the factors that influence heat	67%	Medium
Determine the various types of heat transfer	50%	Medium
Distinguish between heat transfer through convection, conduction, and radiation	33%	Medium
Explaining the phenomenon of heat in everyday life	56%	Medium
Explaining the coefficients of expansion of length, area, and volume	53%	Medium
Explain the properties of expansion caused by temperature and heat	54%	Medium
Average	59%	Medium

In addition to demonstrating the effectiveness of the CLIS model, the DQM results in the moderate category also indicate that the process of conceptual change does not occur immediately, but rather occurs gradually. The varying DQM values between indicators (33%–100%) indicate that the level of concept complexity also influences the success of misconception remediation. Abstract concepts, such as the relationship between heat and temperature changes or the mechanism of expansion of matter, tend to be more difficult to reconstruct than more concrete concepts. This aligns with the findings of Fitria (2022) who stated that the success rate of conceptual change is strongly influenced by the characteristics of the material and the depth of students' initial misconceptions.

The dominant positive change category indicates that most students experienced a shift in their cognitive structure toward a more accurate scientific understanding. From the perspective of conceptual change theory, this shift occurs when students experience cognitive conflict between their initial ideas and the empirical evidence obtained during learning. The CLIS model facilitates this through stages of idea generation, discussion, and conceptual restructuring, allowing students not only to receive new information but also to actively revise their frameworks. This process strengthens the stability of the concepts formed because change occurs through reflection and reexamination, rather than simply memorizing information.

These findings also confirm that the effectiveness of misconception remediation depends not only on the delivery of the material but also on the learning design that provides space for exploration and social interaction. Group discussions and experimental activities in the CLIS model allow students to compare arguments, test hypotheses, and evaluate the suitability of concepts to observed phenomena. This condition strengthens the process of internalizing scientific concepts and reduces the likelihood of persistent misconceptions. Therefore, the moderate DQM scores obtained in this study can be seen as an indicator that the constructivist-based learning intervention makes a real contribution to improving student understanding systematically and sustainably.

Analysis of the Effectiveness of Misunderstanding Correction Using the McNemar Test

The results of statistical analysis using the McNemar test showed a χ^2 value of 32.794 with a significance value of $p = 0.000$ ($\alpha = 0.05$). These results indicate a significant difference between students' conceptual understanding before and after learning using the CLIS model, as seen in Table 5 and 6.

Table 5. McNemar's 2x2 Contingency

Pretest/posttest	No misconceptions	Misconception
No misconceptions	342	36
Misconception	105	17
McNemar nB,nC		32,794

Table 6. McNemar Test Statistics

Statistical test	Value
N (total number of subjects)	500
McNemar χ^2 (Continuity corrected)	32,794
Asymp. Sig. (p-value)	0,000

The McNemar test results showed a significant change in conception after the implementation of the Children Learning in Science (CLIS) model. The Asymp. Sig. value of 0.000 is smaller than the 0.05 significance level, indicating a significant difference between the pre- and post-learning conditions. This finding confirms that the implementation of the CLIS model has a significant impact on shifting students' understanding from misconceptions to more appropriate scientific concepts. These results are in line with previous research showing that constructivism-based learning is effective in encouraging conceptual change when students are given the opportunity to reflect on and evaluate their understanding (Putri et al., 2022).

A 2×2 contingency table analysis showed that the number of changes from misconception to non-misconception categories (105) was greater than the reverse change (36) out of a total of 500 data pairs. This dominance of positive changes indicates that most students successfully revised their initial understanding. Thus, the learning intervention provided not only produced statistical differences but also showed a tendency for substantial conceptual improvement (Sari et al., 2019). The comparison of pretest and posttest results further strengthens that the changes that occurred were a consequence of a structured learning process, as emphasized that the before-after design is effective for assessing the impact of interventions in reducing misconceptions (Rahmawati et al., 2023).

The calculated χ^2 value of 32.794 indicates a significant change at the aggregate level, although only a few indicators partially reached statistical significance. This variation indicates that learning effectiveness can vary for each subconcept, depending on the level of material complexity and the depth of students' initial misconceptions (Lestari et al., 2024). The conceptual change process occurs through the systematic stages of CLIS—orientation, idea generation, restructuring, application, and consolidation—which provide space for students to express initial ideas, test them through discussion and experimentation, and gradually reconstruct concepts. This approach has proven effective because it positions students as active subjects in constructing knowledge, so that the resulting conceptual changes are more meaningful and sustainable (Kurniawan et al., 2016).

Student Responses to Learning with the CLIS Model

The results of the student response questionnaire analysis showed that science learning using the CLIS model received a positive response. The average percentage of student responses was 71%, categorized as good, with a minimum percentage of 50% and a maximum of 80%. These results indicate that most students found CLIS learning interesting, easy to understand, and encouraged active engagement in discussions and learning activities. This can be seen in Table 7.

Table 7. Student Response Score

Information	Value
Number of respondents	25
Lowest Student Score	50
Highest Student Score	80
Average Score of Students	71
average	Good

A total of 25 students who participated in science learning on the topic of temperature, heat, and expansion using the CLIS model provided responses that were mostly in the good category. These findings indicate that the application of CLIS is able to create participatory learning and encourage active student involvement. This involvement arises because the CLIS stages provide space for students to express initial ideas, discuss, make observations, and reflect on learning outcomes, so that the process of knowledge formation takes place constructively in accordance with the principles of constructivism. The presentation of real contexts close to everyday life was the aspect with the highest response because it helped students connect empirical experiences with scientific concepts more meaningfully. These positive responses confirm that the CLIS model not only supports increased conceptual understanding but also builds positive attitudes towards science learning that contribute to the successful correction of misunderstandings.

Conclusion

The implementation of the Children Learning in Science (CLIS) model in science learning about temperature, heat, and expansion in grade VII of UNP Laboratory Development Junior High School went well in accordance with the designed learning syntax. The implementation of the CLIS model was able to improve students' conceptual understanding as indicated by a decrease in the percentage of misconceptions and an increase in the percentage of students who understood the concept after learning. The results of the Reduction in Quantity of Misconceptions (DQM) analysis showed effectiveness in the moderate category, while the McNemar test showed a significant difference between students' conceptual understanding before and after learning. In addition, students' responses to learning using the CLIS model were positive, indicating that this model was able to encourage active student involvement and help them understand the concepts of temperature, heat, and expansion more scientifically.

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Author Contributions
A.F. designed the study, developed the research instruments, conducted the data collection, and performed the data analysis. A.F. also drafted and revised the manuscript. All authors contributed to the interpretation of the results, critically reviewed the manuscript for important intellectual content, and approved the final version of the manuscript.

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