PILLAR OF PHYSICS EDUCATION
Vol. 19 (3), 2026, page.275-283
ISSN (Print) : 2337-9618
ISSN (Online) : 2684-8880

PRELIMINARY RESEARCH ON THE NEED FOR AN E-MODULE BASED ON COGNITIVE CONFLICT, INTEGRATING DEEP LEARNING AND LOCAL WISDOM TO REMEDY STUDENTS' MISCONCEPTIONS REGARDING TEMPERATURE AND HEAT

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ABSTRACT

A correct conceptual understanding is a crucial aspect of physics learning, particularly regarding the abstract topics of temperature and heat, which often lead to misconceptions among students. This study employed *Educational Design Research* (EDR) using the Plomp development model and focused specifically on the *preliminary research* phase. The *preliminary research* involved 36 eleventh-grade students at SMAN 1 Lareh Sago Halaban and used a validated and reliable four-tier multiple-choice diagnostic test, interviews with physics teachers, and an analysis of instructional materials used in the school. The findings revealed that the majority of students (49.2%) were categorized as having misconceptions**,** while 23.9% demonstrated conceptual understanding and 26.9% did not understand the concepts. The highest percentages of misconceptions were found in the indicators of factors causing expansion in bimetals (69.4%) and the thermometric properties of objects (66.7%). Interview results indicated that teachers had not specifically identified students' prior conceptions, while the instructional materials did not facilitate cognitive conflict, deep learning activities, or the integration of local wisdom. These findings indicate the need for an e-module based on cognitive conflict and integrated with deep learning and local wisdom to support the remediation of students' misconceptions regarding temperature and heat.

Keywords :*e-module; cognitive conflict; deep learning; local wisdom; misconception.*

I. INTRODUCTION

21st-century physics education is no longer focused solely on mastering formulas and rote memorization, but rather on meaningful conceptual understanding that can be related to everyday phenomena [1]. Physics concepts are interrelated and systematically organized; thus, errors in understanding basic concepts can affect the understanding of subsequent concepts. Consequently, physics instruction must be designed to help students build a correct conceptual understanding from the very beginning [2]. A solid conceptual understanding is also closely linked to students' scientific thinking skills in explaining phenomena rationally and solving problems logically.

Numerous previous studies have confirmed that errors in understanding physics concepts remain prevalent among students [3]. Misconceptions have been identified as a recurring problem in physics learning [2], including in specific topics such as linear motion and static fluids [4,5]. The recurrence of these findings across various topics indicates that misconceptions are a systemic issue, not merely temporary errors experienced by a small fraction of students. It is important to distinguish this condition from mere conceptual ignorance because, in cases of misconception, students believe their incorrect understanding to be true. Consequently, they tend to retain these conceptions even after receiving instruction. Since misconceptions generally arise from students'

Submitted: 2026-08-18 Accepted: 2026-08-20 Published: 2026-08-20

early experiences and become integrated into their cognitive structure, they are persistent and resistant to change through conventional instruction alone [2,6].

Temperature and heat are topics particularly prone to misconceptions [7], as these concepts are abstract and relate to energy, heat transfer, temperature changes, thermal expansion, and changes in the state of matter. Previous research has shown that students still hold misconceptions regarding the concepts of temperature, heat, and heat transfer [8], as well as regarding thermal expansion and changes in the state of matter. Students tend to view temperature and heat as the same concept, regard heat as a substance that can be transferred, and exhibit misunderstandings regarding Black's principle, temperature conversion, and thermal expansion. A preliminary study was conducted at SMAN 1 Lareh Sago Halaban with 11th-grade students to determine their level of understanding of the concepts of temperature and heat using a valid and reliable four-tier multiple-choice diagnostic test. This instrument was used to identify students' answers, reasoning, and level of confidence in their responses, thereby providing a more in-depth picture of students' conceptual understanding compared to standard multiple-choice tests.

Interviews with physics teachers revealed that students' prior conceptions had not been identified before instruction began, so teachers lacked information about any misconceptions students might bring into the classroom. The instruction that took place was also not specifically designed to address these misconceptions and remained focused on presenting content and providing practice problems. An analysis of the instructional materials used, namely, textbooks, teaching modules, and printed worksheets, revealed that these learning resources already included general components such as the subject matter, learning objectives, a summary of the material, example problems, and practice problems; however, they do not yet include activities to identify students' prior conceptions, cognitive conflict strategies to promote conceptual change, or the integration of local wisdom that can connect physics concepts to students' real-life contexts.

Given these conditions, alternative instructional materials are needed that can help students build a correct conceptual understanding while simultaneously remediating their misconceptions. One alternative that can be used is a cognitive conflict-based e-module combined with a deep learning approach and the integration of local wisdom. The cognitive conflict model can help students recognize the discrepancy between their initial conceptions and scientific concepts, thereby fostering conceptual change [9], while the deep learning approach is particularly effective in helping students understand concepts more deeply through active, reflective, and structured learning activities, ensuring that they not only memorize but also connect concepts to everyday phenomena [10]. The integration of local wisdom makes learning more contextual and meaningful because the material is linked to students' real-world environments and experiences [11]. In the context of Minangkabau culture, for instance, traditional practices such as cooking lamang (glutinous rice steamed inside bamboo over an open fire), marandang (slow-cooking rendang until the coconut milk reduces and caramelizes), making gula aren (boiling palm sap until it thickens and solidifies into palm sugar), and preparing kawa daun (boiling coffee leaves to make a traditional beverage) all involve concrete, observable processes of heat transfer, temperature change, and changes in the state of matter that are directly relevant to the topic of temperature and heat. The novelty of this study lies in the integration of cognitive conflict, deep learning, and local wisdom into an e-module specifically designed to support the remediation of students' misconceptions regarding temperature and heat. These components are integrated to support students in identifying their initial conceptions, recognizing discrepancies between their conceptions and scientific concepts, developing deeper understanding, and connecting physics concepts with meaningful local contexts.

The Plomp model was chosen because its *preliminary research* phase provides a systematic process for identifying learning problems, analyzing learning contexts, and determining the characteristics of the solution before the product development stage. This is relevant to the present study because the development of an e-module for misconception remediation requires an initial analysis of students' conceptual understanding, learning conditions, and instructional materials [12]. This article presents the results of the *preliminary research* phase in the development of an e-module based on cognitive conflict, integrated with *deep learning* and local wisdom, to remediate students' misconceptions regarding temperature and heat. Specifically, this study aims to identify students' misconceptions and the contextual factors associated with them and to determine the characteristics of the e-module needed to support misconception remediation.

II. METHOD

This is an Educational Design Research (EDR) study employing Plomp's development model, which consists of a *preliminary research* phase, a *development or prototyping phase*, and an *assessment phase* [12]. This article specifically discusses the *preliminary research* phase, which was carried out through three activities: analysis of the need for misconception remediation, analysis of the contextual causes of misconceptions, and a literature review**.** The analysis of the need for misconception remediation was conducted to obtain an overview of students' conceptual understanding of temperature and heat. The analysis of the contextual causes of misconceptions was conducted to identify learning conditions, instructional practices, and instructional materials related to students' misconceptions. The literature review was then conducted based on the problems identified through the needs and context analyses to determine relevant solutions and the characteristics of the e-module to be developed.

1) Analysis of the Need for Misconception Remediation

The preliminary study was conducted at SMAN 1 Lareh Sago Halaban, involving one physics teacher and 36 11th-grade students in Class F who had studied the topics of temperature and heat. Data for the analysis of the need for misconception remediation were collected using a 10-item four-tier multiple-choice diagnostic test adopted from a previous study [13]**.** The instrument had previously undergone validity and reliability testing [13]. The instrument was used to identify students' conceptual understanding based on their answers, justifications, level of confidence in their answers, and level of confidence in their justifications. Data collection for the needs analysis was conducted by administering the diagnostic test to the students. Data from the diagnostic test were analyzed using quantitative descriptive methods by grouping students into the categories of conceptual understanding, misconceptions, and lack of conceptual understanding based on response patterns across the four tiers of the instrument: answer, confidence in the answer, reasoning, and confidence in the reasoning. The percentage for each category was calculated to provide an overview of students' conceptual understanding both overall and for each indicator of temperature and heat.

2) Analysis of the Contextual Causes of Misconceptions

The analysis of the contextual causes of misconceptions was conducted through a semi-structured interview with one physics teacher, a student needs questionnaire, and an analysis of the instructional materials used at the school. The instructional materials analyzed included textbooks, teaching modules, and worksheets. The interview was conducted to obtain information regarding the learning process, identification of students' prior conceptions, learning strategies, use of instructional materials, and efforts made to address misconceptions. The student needs questionnaire was used to obtain information regarding students' learning conditions and their needs for instructional materials. Data collection was conducted on April 7, 2026. SMAN 1 Lareh Sago Halaban was selected as the research site because the school was relevant to the preliminary investigation of students' conceptual understanding and the learning conditions related to temperature and heat. Data from interviews, student needs questionnaires, and instructional material analyses were analyzed descriptively to obtain an overview of the learning context, student needs, and the instructional material components that were already available and those that had not yet been addressed. The results of the contextual analysis were used to identify problems related to the identification of students' prior conceptions, the implementation of cognitive conflict, *deep learning*, the integration of local wisdom, and the remediation of misconceptions.

3) Literature Review

The literature review was conducted after the needs analysis and context analysis had identified the problems and learning conditions. Relevant research findings and scientific sources were examined to determine appropriate solutions to the identified problems and the characteristics of the e-module to be developed. The literature review focused on e-modules, cognitive conflict, *deep learning*, local wisdom, and misconception remediation. In particular, the literature review examined the potential of cognitive conflict to facilitate conceptual change, *deep learning* to promote meaningful, mindful, and joyful learning, and local wisdom to contextualize physics concepts through students' everyday experiences.

The results of the literature review were subsequently synthesized with the findings from the needs and context analyses to determine the solution and characteristics of the instructional material to be developed. Based on this synthesis, the proposed solution was an e-module based on cognitive conflict, integrated with *deep learning* and local wisdom, to support the remediation of students' misconceptions regarding temperature and heat. The local wisdom considered in the development includes the preparation of lamang, the preparation of rendang, the production of palm sugar, and kawa daun, which provide contextual situations for connecting temperature and heat concepts with students' everyday environment.

III. RESULTS AND DISCUSSION

1) Analysis of Remediation Needs Misconceptions

An analysis of students' misconceptions was conducted to determine the extent of their understanding of temperature and heat, and to identify the instructional materials needed to address these misconceptions. Data were collected using a four-tier multiple-choice diagnostic test administered to eleventh-grade students at SMAN 1 Lareh Sago Halaban. The results showed that students' conceptual understanding of temperature and heat remained relatively low, with misconceptions being the most frequently identified category. A summary of the diagnostic test results is presented in Table 1.

Table 1. Summary of Diagnostic Results on Students' Conceptual Understanding

Category	Number	Percentage (%)
Conceptual Understanding	86	23.9
Misconceptions	177	49.2
Lack of Understanding of the Concept	97	26.9

As shown in Table 1, students with misconceptions accounted for the highest proportion (49.2%), compared with only 23.9% who demonstrated conceptual understanding and 26.9% who did not understand the concepts at all. The markedly higher proportion of misconceptions relative to genuine conceptual understanding indicates that students' difficulties with temperature and heat are not simply a lack of understanding but reflect misconceptions that are already firmly established. Instruction is therefore needed that not only explains the concepts but also helps students recognize and correct these misconceptions. A further analysis was conducted for each indicator of the temperature and heat material to identify which subconcepts were most affected by misconceptions, since students' level of difficulty can vary across indicators. The results of this analysis served as a reference for determining which topics should be emphasized in the remedial teaching materials to be developed. The complete results are presented in Table 2.

Table 2 shows that misconceptions occur in nearly all indicators related to temperature and heat. The highest percentages of misconceptions were found in the indicators "analyzing the factors causing expansion in a bimetal" (69.4%) and "identifying the thermometric properties of an object" (66.7%). The high percentages for these two indicators suggest that students still struggle to understand the basic concepts related to the thermometric properties of objects and the expansion process caused by temperature changes. These two indicators should be a primary focus in the development of the e-modules.

Misconceptions were also relatively high for converting temperature from the Celsius to the Kelvin scale (55.6%), applying Black's principle to determine the final temperature of a mixture (50.0%), and determining the factors affecting heat capacity (50.0%). Because these three indicators all require students to relate several physical quantities to solve problems, students' difficulties appear to lie not only in conceptual understanding but also in applying concepts to calculations and problem-solving. The e-module being developed therefore needs to strengthen both conceptual understanding and students' ability to apply these concepts.

Table 2. Percentage of Students' Conceptual Understanding for Each Indicator of Temperature and Heat

No	Category	Concept Understanding (%)	Misconceptions (%)	Does Not Understand the Concept (%)
1.	Identifying the thermometric properties of an object	19.4	66.7	13.9
2.	Converting temperature from the Celsius scale to Kelvin	25.0	55.6	19.4
3.	Identifying the process of a substance's phase change	33.3	30.6	36.1
4.	Determining the relationship between the Celsius and Fahrenheit scales	38.9	36.1	25.0
5.	Using the calibration equation for a Celsius thermometer with another temperature scale	19.4	44.4	36.1
6.	Using the heat equation to determine the amount of heat required by an object	19.4	47.2	33.3
7.	Using Black's law to determine the final temperature of a mixture	13.9	50.0	36.1
8.	Analyzing the factors causing expansion in bimetal	16.7	69.4	13.9
9.	Analyzing the effect of the coefficient of linear expansion on the increase in metal length	36.1	41.7	22.2
10	Determining the factors that affect the heat capacity of a substance	16.7	50.0	33.3

Overall, these findings point to a persistent gap between students' actual and expected levels of conceptual understanding. The high incidence of misconceptions across indicators underscores the need for e-modules that give students opportunities to articulate their prior understanding, recognize discrepancies with scientific concepts, and then construct more accurate understanding, a process consistent with the principles of cognitive-conflict-based learning, which emphasizes reconciling students' prior conceptions with scientific facts. These diagnostic results thus provide the empirical foundation for developing an e-module to remediate students' misconceptions about temperature and heat.

2) Analysis of the Context Leading to Misconceptions

An analysis of the context underlying students' misconceptions was conducted to gain insight into the learning conditions and instructional materials used in physics teaching at SMAN 1 Lareh Sago Halaban, with specific reference to temperature and heat. This analysis drew on interviews with two physics teachers and an examination of the instructional materials in use, namely teaching modules and worksheets. The interviews revealed a consistent set of findings: students' prior conceptions had not been specifically identified; lessons had not been designed to facilitate cognitive conflict or deep-learning activities; local wisdom had not been integrated into the instructional materials; and teachers lacked specific strategies for remediating misconceptions. The instructional materials were then examined to identify which learning components were present and which were still lacking; the complete results are presented in Table 3.

Table 3. Results of the Learning Context Analysis Based on Teacher Interviews and Teaching Materials Analysis

Aspects Analyzed	Findings	Implications for Needs E-Modules
Identification of Students' Prior Concepts	Teachers have not identified students' prior conceptions before instruction begins, so they have not obtained information regarding the students' prior conceptions and misconceptions.	Teaching materials that include activities to identify students' prior conceptions are needed as a basis for facilitating cognitive conflict.
Teaching Strategies Used by Teachers	Instruction still focuses on presenting material and providing practice problems and has not specifically included activities that encourage students to develop deep and reflective	Learning activities that integrate *deep learning* are needed so that students do not merely memorize concepts but build a deeper and more meaningful

Aspects Analyzed	Findings	Implications for Needs E-Modules
	understanding.	understanding.
Structure of instructional materials (textbooks, teaching modules, worksheets)	These materials already include general learning components (subject identification, learning objectives, content summaries, sample questions, and practice exercises), but do not yet include activities for identifying prior conceptions or cognitive conflict strategies.	E-modules are needed that explicitly integrate the stages of cognitive conflict to support the process of conceptual change.
Incorporation of local wisdom in instructional materials	The instructional materials currently in use do not link physics concepts to local wisdom or students' real-world experiences in their surrounding environment.	Integration of local wisdom is needed to make the teaching of temperature and heat more contextual and meaningful.
Facilitating the remediation of misconceptions	The instructional materials do not yet provide activities specifically designed to identify and remediate students' misconceptions.	Teaching materials are needed that facilitate the process of addressing misconceptions through structured learning activities.

As shown in Table 3, the instructional materials currently used in schools include several general learning components but do not yet fully address the needs of misconception remediation. Specifically, they lack activities for identifying students' prior conceptions, a cognitive-conflict-based learning syntax to support conceptual change, activities that support deep learning, and any integration of local wisdom. Nor do they include activities specifically designed to identify and correct students' misconceptions.

These findings point to a gap between the conceptual-understanding problems identified in the diagnostic test and the characteristics of the instructional materials currently available in schools. This gap arises both from teachers' limited readiness to identify students' prior conceptions and from the structure of the materials themselves, neither of which has been designed to address the root causes of misconceptions. Developing an e-module that integrates cognitive conflict, deep learning, and local wisdom is therefore necessary to support the remediation of students' misconceptions about temperature and heat. Together with the diagnostic findings in the previous section, this contextual analysis reinforces the urgency of developing such an e-module as a response to the causes of misconceptions identified during the *preliminary research* phase.

3) Literature Review of E-Modules Based on Cognitive Conflict Integrated with Deep Learning and Local Wisdom to Remediate Misconceptions

E-modules are a form of digital instructional material that present learning content and activities in a structured manner while allowing for the integration of various forms of learning media [13]. As a form of electronic teaching material, e-modules are commonly described as self-instructional, self-contained, and adaptive, which enables them to guide students through activities that go beyond content delivery, including structured practice and self-directed engagement with the material, rather than functioning as static text [14]. These characteristics make e-modules well suited for systematically incorporating learning stages tailored to students' needs, and for integrating the strategies and contexts required to remediate misconceptions.

Cognitive conflict is a strategy that can support conceptual change by exposing the discrepancy between students' initial conceptions and the scientific phenomena or concepts they encounter [15]. Confronting this discrepancy prompts students to recognize that their existing conceptions do not align with scientific explanations, encouraging them to re-examine their understanding. This process of re-examination is central to misconception remediation, since students come to understand not only the correct answer but also the reasoning behind the shift in their understanding. The stages of cognitive conflict therefore need to be integrated into the e-module to help students surface their initial conceptions, confront the conflict, and construct understanding that better aligns with scientific concepts.

Deep learning, in addition to cognitive conflict, can support a learning process that emphasizes deep and meaningful understanding [16]. Recent Indonesian education literature frames this approach around three interconnected pillars, mindful learning, meaningful learning, and joyful learning, which together encourage students to learn with conscious awareness, to connect new material to knowledge and experience they already have, and to experience the learning process positively rather than as rote memorization [17]. Applying these principles can help students understand the relationships between concepts, apply concepts in relevant contexts, and reflect on their own learning process. Integrating deep learning into the e-module can therefore strengthen students' understanding and reflection once cognitive conflict has been experienced.

Local wisdom can serve as a learning context that connects physics concepts to phenomena and activities close to students' daily lives. Drawing on local contexts helps students relate what they are learning to real-world experience, making learning more contextual and meaningful [18]. For temperature and heat, local wisdom can be linked to activities or phenomena in students' surroundings that relate to temperature, heat, heat transfer, and changes in the state of matter. Integrating local wisdom into the e-module can therefore provide a real-world context that helps students understand physics concepts while connecting them to their everyday lives.

Taken together, these four components play complementary roles in remediating students' misconceptions: the e-module serves as the platform for presenting learning stages and activities; cognitive conflict helps students recognize the discrepancy between their initial conceptions and scientific concepts; deep learning supports understanding and reflection; and local wisdom provides a context closely tied to students' experience. Integrating these approaches allows the learning process to be designed not only to convey concepts but also to facilitate deep, meaningful, and contextual conceptual change. The solution proposed in this study is accordingly the development of a cognitive-conflict-based e-module that integrates deep learning and local wisdom to remediate students' misconceptions about temperature and heat.

IV. CONCLUSION

The results of the *preliminary research* indicate that 11th-grade students at SMAN 1 Lareh Sago Halaban still exhibit a relatively high prevalence of misconceptions regarding the topics of temperature and heat. The four-tier multiple-choice diagnostic test results revealed a misconception rate of 49.2%, while 23.9% of students understood the concepts and 26.9% did not. The highest rates of misconceptions were found in the indicators for analyzing the factors causing expansion in bimetal (69.4%) and identifying the thermometric properties of an object (66.7%).

The results of the contextual analysis were based on teacher interviews and an analysis of instructional materials. These results indicate that the learning process has not specifically identified students' prior conceptions or facilitated the remediation of their misconceptions. The instructional materials used also did not include cognitive conflict strategies, activities that support deep learning, or the integration of local wisdom into the learning process. The results of the literature review indicate that e-modules can serve as a platform for integrating learning activities that support conceptual change, while cognitive conflict, deep learning, and local wisdom play complementary roles in supporting conceptual understanding and the remediation of misconceptions. It is worth noting that this preliminary research relied primarily on a single research site and a relatively limited set of data collection instruments (diagnostic tests, interviews, and document analysis), which may limit the generalizability of the findings to other schools or student populations. Nevertheless, the results provide a solid empirical basis for the subsequent development stage.

Based on the overall *preliminary research* results, the e-module will be designed using a cognitive conflict approach and will integrate deep learning and local wisdom to remediate students' misconceptions regarding temperature and heat. This e-module is intended to identify students' prior conceptions, facilitate the occurrence of cognitive conflict, promote deep and meaningful understanding, and relate the concepts of temperature and heat to local wisdom contexts that are close to students' experiences. It is expected that this e-module will not only reduce the prevalence of misconceptions but also offer teachers a practical, ready-to-use instructional resource that connects scientific concepts with students' local cultural context, thereby making physics learning more meaningful and contextually relevant. The results of this *preliminary research* will subsequently serve as the foundation for determining the characteristics and components of the e-module during the *development or prototyping phase.*

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