Lontar Physics Today (e-ISSN: 2828-0970)
Vol. 5 No. 2 June 2026, p 199-218
Available online at http://journal3.upgris.ac.id/index.php/lpt/index
DOI: 10.26877/lpt.v5i2.503

Implementing Experiential Learning with Simple Media to Improve Cognitive Learning Outcomes on Heat Concepts

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Article Info:

Article History:
received: 2 April 2026
accepted: 11 May 2026
available online: 12 May 2026

Keyword:
cognitive learning outcomes, experiential learning model, heat, simple media

https://doi.org/10.26877/lpt.v5i2.503

Abstract:

This study examines the implementation of an experiential learning model supported by simple instructional media in teaching heat, with a focus on students' cognitive learning outcomes. A quasi-experimental design with a posttest-only control group was employed, involving two Grade XI science classes at SMAN 10 Pekanbaru (n = 78). Data were collected using a 17-item multiple-choice test developed based on Bloom's Taxonomy (C1–C6) and analyzed using descriptive statistics, including the mean, median, mode, and standard deviation. The results show that the experimental class achieved a higher mean posttest score (74.66; SD = 14.78) compared to the control class (68.63; SD = 18.43). In addition, a greater proportion of students in the experimental class were classified into the high and very high categories. These findings indicate a more favorable distribution of cognitive learning outcomes in the experimental group, particularly in higher-order cognitive levels. This study highlights the potential of integrating experiential learning with simple instructional media as a practical approach to support meaningful learning and the development of higher-order thinking skills in physics education, especially in resource-limited settings. Future research is recommended to employ inferential analysis and more rigorous research designs to further examine the effectiveness of this approach.

1. Introduction

Cognitive learning outcomes represent students' intellectual abilities in understanding, applying, analyzing, and evaluating knowledge, which are essential competencies in 21st-century education (Priscilia & Haryani, 2025). These outcomes are commonly categorized based on Bloom's revised taxonomy, ranging from lower-order thinking skills such as remembering (C1) and understanding (C2), to higher-order thinking skills, including applying (C3), analyzing (C4), evaluating (C5), and creating (C6) (Nafiati, 2021). However, many studies have reported that students' cognitive learning outcomes, particularly at higher-order levels, remain relatively low in science learning contexts.

This low level of achievement is closely linked to instructional practices that remain predominantly teacher-centered, which restrict students' opportunities to actively construct knowledge through meaningful learning experiences (Ma'ruf et al., 2024). Consequently, students tend to rely heavily on rote memorization rather than developing deeper conceptual understanding and higher-order thinking skills. Therefore, innovative instructional approaches are required to enhance students' cognitive learning outcomes by fostering active engagement, direct experience, and reflective thinking, as supported by previous studies on student-centered learning models (Wulandari et al., 2024).

In line with the importance of improving cognitive learning outcomes, the quality of a nation is closely related to the quality of its education system, as human resources are largely shaped through education. In the era of globalization, marked by rapid developments in science and technology, the demand for high-quality human resources continues to increase. Therefore, the learning process in schools needs to be designed innovatively to support the development of students' cognitive abilities and higher-order thinking skills, including critical thinking, problem-solving, creativity, and adaptability (Hafeez, 2021).

In the context of science education, particularly physics learning, the instructional process is not only aimed at delivering scientific concepts but also at developing students' scientific thinking skills and science process skills. Physics, as a branch of natural sciences, examines natural phenomena through observation, experimentation, and scientific analysis (Souhoka & Mesdila, 2021). Therefore, physics learning should provide opportunities for students to actively engage in scientific inquiry to construct a deeper and more meaningful understanding of concepts. However, several studies indicate that physics learning in schools still faces challenges that hinder the optimal achievement of learning objectives (Fazira et al., 2024).

One common problem in physics learning is the limited opportunities for students to actively construct knowledge through meaningful learning experiences. This issue is influenced not only by the abstract nature of physics concepts but also by the use of instructional methods that remain predominantly teacher-centered (Ma'ruf et al., 2024). Lecture-based instruction tends to make students passive, as they primarily receive information without actively participating in the learning process. As a result, students' conceptual understanding becomes less meaningful and tends to rely on memorization rather than developing higher-order thinking skills.

These challenges are also commonly identified in physics learning contexts, where instructional practices are still dominated by teacher-centered approaches that limit students' active participation in constructing scientific concepts. Similar conditions were observed during preliminary observations conducted at SMAN 10 Pekanbaru, which served as the research setting of this study.

These problems can be addressed by implementing learning models that promote active student engagement, such as experiential learning. This model emphasizes learning through direct experience, allowing students to construct knowledge based on their learning experiences (Lutfiyah & Mardana, 2022) . In this approach, students are actively involved in the learning process, not only as recipients of information but also as participants who experience and reflect on the concepts being learned (Rashid et al., 2024).

In addition to appropriate learning models, the use of instructional media also plays an important role in supporting the learning process. Abstract physics concepts can be made more concrete through the use of media, making them easier for students to understand. One type of media that can be utilized is simple or low-cost instructional media, which are easy to obtain, inexpensive, and suitable for classroom demonstrations and simple experiments. The use of such media enables students to engage in both hands-on and minds-on activities, allowing abstract physics concepts to become more observable and meaningful during the learning process (Herlina et al., 2020).

Heat is one of the physics topics that is highly suitable for learning through direct experience and experimental activities. The concept of heat involves various phenomena such as heat transfer, temperature changes, and changes in the state of matter, which can be observed through simple experiments (Fegi et al., 2021).

Research by Santhalia & Yuliati (2021) indicates that experiential learning enhances students' scientific literacy, while Rashid et al. (2024) found that it helps students relate physics concepts to everyday phenomena. Lutfiyah et al., (2022) reported that students taught using experiential learning demonstrated better cognitive learning outcomes compared to those taught using conventional instruction. Similarly, Wardhana et al. (2024) found that experiential learning contributed to improved students' conceptual understanding. In addition, Nurnaifah et al., (2023) showed that experiential learning contributed to the improvement of students' cognitive achievement. Furthermore, the use of simple instructional media has also been proven to support physics learning. Fegi et al. (2021) found that experiment-based learning using simple instructional media had a positive effect on students' understanding of physics concepts. These findings are strengthened by Herlina et al. (2020), who reported that simple or low-cost teaching aids not only enhance science process skills but also improve conceptual understanding and problem-solving abilities through hands-on and minds-on activities.

However, despite these positive findings, students' cognitive learning outcomes in physics, particularly on heat topics, remain a challenge in many learning contexts. Students often struggle to understand abstract concepts, apply heat principles in problem-solving situations, and develop higher-order thinking skills. Learning outcomes are often limited to lower cognitive levels, such as remembering and understanding, while students' abilities to analyze, evaluate, and apply concepts meaningfully remain relatively low. These shortcomings indicate that physics learning has not fully facilitated meaningful knowledge construction and active cognitive engagement.

Improving cognitive learning outcomes requires learning experiences that actively involve students in constructing knowledge rather than passively receiving information. Therefore, instructional approaches that emphasize direct experience, reflection, and active participation are needed to support deeper conceptual understanding and higher-order thinking skills. Experiential learning provides students with opportunities to construct knowledge through direct experience and reflective thinking. Through the stages of concrete experience, reflective observation, abstract conceptualization, and active experimentation, students are encouraged to connect theoretical concepts with real-life phenomena, thereby promoting deeper conceptual understanding and improving cognitive learning outcomes. This approach also supports the development of higher-order thinking skills because students actively investigate, analyze, and interpret learning experiences.

The effectiveness of experiential learning can be further strengthened by using simple instructional media. Simple media help transform abstract physics concepts into observable phenomena and enable students to engage in hands-on, minds-on learning activities. Through direct observation and simple experimentation, students can more easily understand heat concepts and relate them to everyday experiences, making learning more meaningful and cognitively engaging.

Heat is a physics topic well suited to experiential learning, as students can directly observe and investigate heat phenomena through simple experiments and real-life experiences. Therefore, integrating experiential learning with simple instructional media is expected to support improvements in students' cognitive learning outcomes in learning heat concepts. Accordingly, this study aims to analyze students' cognitive learning outcomes after the implementation of an experiential learning model supported by simple instructional media in teaching heat at the high school level.

2. Theoretical Framework

2.1. Nature of Physics Learning

Learning is an interactive process involving students, teachers, instructional strategies, and learning resources to achieve educational objectives (Faizah & Kamal, 2024). Effective learning emphasizes active student engagement, critical thinking, and meaningful interaction rather than passive information transfer. In physics education, learning is not only aimed at mastering concepts but also at developing scientific thinking skills and science process skills (Souhoka & Mesdila, 2021).

Physics, as a branch of natural sciences, studies natural phenomena through observation, measurement, and experimentation, producing systematic knowledge in the form of concepts, principles, and laws (Jeong et al., 2025). Therefore, physics learning should actively involve students in scientific inquiry processes to promote deeper conceptual understanding. In the context of 21st-century education, learning should also foster higher-order thinking skills, including critical thinking, problem solving, and creativity (Priscilia & Haryani, 2025).

2.2. Constructivist Learning Theory

Constructivist theory posits that knowledge is actively constructed by learners through experience and reflection, rather than passively received (Nurhasnah et al., 2024). This theory emphasizes the role of active engagement, prior knowledge, and social interaction in the learning process. Piaget's theory highlights cognitive development through assimilation and accommodation, while Vygotsky emphasizes the importance of social interaction in the zone of proximal developmentS.

In physics learning, constructivism is implemented through activities such as experimentation, observation, and reflection, enabling students to connect abstract concepts with real-world phenomena (Fegi et al., 2021). This approach supports meaningful learning, particularly in abstract topics such as heat, where students often experience misconceptions.

2.3. Experiential Learning Model

Experiential learning is a learning model that emphasizes the construction of knowledge through direct experience. The learning process follows a cyclical pattern consisting of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Cheng et al., 2025). This cycle enables learners to actively construct knowledge through experiencing, reflecting, conceptualizing, and applying, in line with constructivist learning principles.

In the concrete experience stage, students are directly involved in learning activities such as observing phenomena or conducting simple experiments. This stage provides real experiences as the basis for understanding concepts. In the reflective observation stage, students analyze and reflect on these experiences to identify relationships and patterns. The abstract conceptualization stage involves forming concepts or principles based on reflection, while in the active experimentation stage, students apply their understanding to solve problems or test ideas in new situations. In the context of this study, these stages play an important role in supporting students' cognitive learning outcomes, particularly in understanding concepts, applying principles, and solving problems related to heat. Through this structured process, experiential learning facilitates deeper conceptual understanding and enables students to actively construct knowledge (Lutfiyah et al., 2022). Therefore, experiential learning is considered an appropriate approach to improve students' cognitive learning outcomes in physics learning.

2.4. Simple Instructional Media

Simple instructional media refer to low-cost and easily accessible tools that can be used in classroom learning, particularly for demonstrations and simple experiments. These media typically utilize everyday materials such as glass containers, plastic bottles, aluminum foil, or other locally available resources (Fauzi Fahmi et al., 2021). In this study, simple instructional media are specifically used to support the implementation of experiential learning through hands-on and minds-on activities (Siregar et al., 2022).

The use of simple media enables students to directly observe physical phenomena, particularly in heat-related topics such as heat transfer (conduction, convection, and radiation), temperature changes, and thermal expansion, using simple tools such as glass containers, plastic bottles, or other everyday materials.

Furthermore, simple instructional media play a crucial role in facilitating the stages of experiential learning. During the concrete experience stage, students engage in simple experiments using these media. In the reflection and conceptualization stages, the observed phenomena help students construct and relate concepts to scientific principles. Finally, in the experimentation stage, students apply their understanding to solve problems (Fegi et al., 2021). Therefore, the use of simple instructional media is closely related to the development of students' cognitive learning outcomes, particularly in understanding concepts, applying principles, and solving problems (Fazira et al., 2024). By providing direct and meaningful learning experiences, simple media supports the improvement of students' cognitive learning outcomes in physics learning.

2.5. Cognitive Learning Outcomes

Cognitive learning outcomes in this study refer to students' intellectual abilities in understanding and processing knowledge related to heat concepts. These abilities are based on the revised Bloom's Taxonomy by Anderson and Krathwohl, which includes six levels: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) (Nafiati, 2021).

At the remembering level (C1), students are expected to recall basic concepts such as definitions of heat and temperature. At the understanding level (C2), students interpret and explain relationships between concepts. At the applying level (C3), students use formulas or principles to solve problems. At the analyzing level (C4), students examine relationships between variables and identify patterns in physical phenomena. At the evaluating level (C5), students assess solutions or compare different approaches to solving problems. At the creating level (C6), students generate ideas or propose solutions related to heat phenomena. In the context of physics learning, particularly in heat topics, these cognitive abilities are essential for helping students understand abstract concepts, distinguish between related phenomena, and solve problems systematically (Fitriani, 2023). Therefore, cognitive learning outcomes in this study are measured based on students' performance across the six cognitive levels (C1–C6), with an emphasis on conceptual understanding and problem-solving abilities.

2.6. Heat as a Learning Topic

Heat is an important topic in physics that involves concepts such as temperature, heat transfer, and changes in the state of matter. These concepts are often abstract and can lead to misconceptions if not taught effectively (Yeo et al., 2001). Therefore, learning approaches that provide direct experience, such as experimentation, are essential. Experiential learning supported by simple media is particularly suitable for teaching heat concepts. Through simple experiments, students can observe phenomena such as thermal expansion, heat transfer, and energy changes, making abstract concepts more concrete and understandable (Fegi et al., 2021).

3. Method

This study employed a quasi-experimental design using a posttest-only control group design, in which the experimental group received the treatment while the control group did not (Creswell & Poth, 2016). The design was used to examine the implementation of the experiential learning model supported by simple instructional media on students' cognitive learning outcomes.

The study was conducted at SMAN 10 Pekanbaru during the second semester of the 2025/2026 academic year. The population consisted of all students of grade XI MIPA, comprising five classes. The sampling technique employed was purposive sampling, based on criteria such as similar physics learning schedules and relatively homogeneous cognitive ability levels. Based on these criteria, two classes were selected as the sample, namely XI MIPA 1 and XI MIPA 2, each comprising 39 students, for a total of 78 students. The assignment of experimental and control groups was determined through random assignment (lottery) to ensure objectivity. The results indicated that class XI MIPA 1 was assigned as the experimental class, while class XI MIPA 2 served as the control class.

The instructional material implemented in this study was the topic of Heat and Temperature, focusing on the subtopic of Heat. The research instrument consisted of 17 multiple-choice items, each with four answer options, developed based on cognitive indicators from Bloom's Taxonomy (C1–C6). The complete instrument for assessing cognitive learning outcomes is presented in Appendix A. Prior to administration as a posttest, the instrument was validated through expert judgment using Aiken's V index to ensure content validity. The results of the instrument validation and content validity analysis are presented in Appendix B. The distribution of the test items across cognitive levels is presented in Table 1.

Table 1. *Distribution of Test Items Based on Cognitive Levels*

Cognitive Level	Indicator	Number of Items	Item Numbers
Remembering (C1)	Recall basic concepts	2	1, 7
Understanding (C2)	Explain concepts	1	3
Applying (C3)	Apply formulas/principles	5	2, 4, 8, 9, 15
Analyzing (C4)	Analyze relationships/data	5	5, 10, 11, 13, 16
Evaluating (C5)	Evaluate solutions/arguments	3	6, 12, 14
Creating (C6)	Design solutions	1	17

The instructional media used in this study were simple tools designed to assist students in understanding heat concepts through direct experimentation. For thermal expansion, a sealed container filled with colored liquid and equipped with a straw was used to observe changes in volume when heated. To demonstrate Black's principle, students used containers of hot and cold water along with thermometers to observe heat exchange and temperature equilibrium. For specific heat, students compared temperature changes in different substances subjected to the same heat source. Latent heat was demonstrated through ice melting experiments, where students observed temperature changes during phase transitions. For heat transfer, particularly radiation, containers with different surface characteristics (dark and shiny) were used to compare heat absorption and emission. These media were selected because they are easy to obtain, simple to construct, and effective in supporting hands-on and minds-on learning activities. Examples of the simple media used in this study are presented in Figure 1.

Figure 1. *Simple Instructional Media on Heat concepts*

To provide a clearer description of how the instructional media were used in the learning process, the implementation of experiential learning in the experimental class was carried out through three main experimental activities.

In the first experiment, students investigated thermal expansion in liquids by observing changes in liquid volume using a sealed container equipped with a straw. The container was heated using hot water, allowing students to observe the rise in liquid level as an indicator of expansion. This activity facilitated students' ability to recall prior knowledge (C1), understand the relationship between temperature and volume (C2), and analyze observed changes (C4).

In the second experiment, students explored Black's principle and latent heat through heat exchange and phase change activities. They conducted a mixing experiment using hot and cold water to observe temperature equilibrium, and an ice melting experiment to identify latent heat characteristics. These activities required students to apply formulas (C3), analyze experimental data (C4), and evaluate the consistency between theoretical and experimental results (C5).

In the third experiment, students examined heat transfer by radiation by comparing containers with different surface characteristics (dark and shiny). They identified which surface absorbed and retained heat more effectively and explained the results based on the Stefan–Boltzmann principle. This activity facilitated higher-order thinking skills, including analyzing (C4), evaluating (C5), and constructing scientific explanations (C6). The implementation of experiential learning integrated with simple instructional media is summarized in Table 2.

Table 2. *Implementation of Experiential Learning Integrated with Simple Media*

Experiential Learning Stage	Learning Activities	Heat Concept	Cognitive Indicators
Concrete Experience	Students observe expansion, heat mixing, and melting processes through experiments	Expansion, Black's principle, latent heat	C1, C2
Reflective Observation	Students reflect on experimental results and identify relationships	Temperature volume relationship, heat equilibrium	C2, C4
Abstract Conceptualization	Students formulate concepts and apply formulas	Specific heat, latent heat	C3, C4, C5
Active Experimentation	Students apply concepts to new situations (radiation experiment)	Heat transfer (radiation)	C4, C5, C6

Descriptive analysis was used in this study to describe students' cognitive learning outcomes based on the posttest scores obtained. The calculation of students' learning outcome scores, according to Sari et al., (2024), was performed using the formula $S = \left(\frac{S_{obt}}{S_{max}}\right) \times 100$, where S_{obt} represents the obtained score and S_{max} is the maximum possible score. The scores obtained by students were then classified into five categories of learning outcome achievement levels, as presented in Table 3.

Table 3. *Classification of Students' Cognitive Learning Outcomes*

Percentage (%)	Category
$85 < X \leq 100$	Very High
$70 < X \leq 85$	High
$55 < X \leq 70$	Moderate
$40 < X \leq 55$	Low
$0 < X \leq 40$	Very Low

Source : (Amir & Arsyad, 2017)

Descriptive statistical measures, including mean, median, mode, and standard deviation, were calculated to describe the distribution of students' learning outcomes. The interpretation of results was based on a comparison of descriptive statistics between the experimental and control groups to determine differences in students' cognitive learning outcomes after the implementation of experiential learning supported by simple media.

4. Result

Students' cognitive learning outcomes on the topic of heat, obtained through a posttest administered after the learning process, constituted the data used in this study. These data were then analyzed using descriptive statistics, including the mean, median, mode, and standard deviation, as presented in Table 4.

Table 4. *Results of Descriptive Statistical Analysis*

Description	Experimental Class	Control Class
Mean	74.66	68.63
Median	70.59	70.59
Mode	64.71 & 82.35	70.59
Standard Deviation	14.78	18.43

Based on the results of the analysis, the experimental class generally showed better learning outcomes compared to the control class, as indicated by its higher mean score. The identical median values in both classes suggest that the central tendency is relatively similar; this may be attributed to comparable score distributions around the middle range, where a substantial proportion of students in both groups achieved moderate scores. However, differences in data distribution are evident from the mode and standard deviation. The experimental class exhibited two mode values, indicating variations in student achievement at certain levels, whereas the control class tended to be concentrated at a single value. In addition, the higher standard deviation in the control class indicates a wider spread of scores, while the lower standard deviation in the experimental class reflects a more homogeneous distribution.

The overall results indicate that learning in the experimental class not only produced a higher mean score but also demonstrated a more evenly distributed pattern of learning outcomes compared to the control class. To provide a more detailed description of the levels of students' cognitive learning outcome achievement, the posttest data from both classes (*n* representing the number of students) were subsequently classified into several categories, as presented in Table 5.

Table 5. *Distribution of Students' Cognitive Learning Outcomes in the Posttest on the Topic of Heat*

Score Range	Category	Experimental Class		Control Class	
		n	Percentage (%)	*n*	Percentage (%)
$85 < X \leq 100$	Very High	10	26	6	15
$70 < X \leq 85$	High	14	36	19	49
$55 < X \leq 70$	Moderate	10	26	7	18
$40 < X \leq 55$	Low	5	13	3	8
$0 < X \leq 40$	Very Low	0	0	4	10
Mean		74.66		68.63	
Category		High		Moderate	

The distribution of students' cognitive learning outcomes presented in Table 5 indicates that the experimental class shows a better tendency compared to the control class. The absence of students in the very low category, along with the higher proportion of students in the very high category, serves as a key indicator of this condition. In contrast, the presence of students in the very low category in the control class suggests that disparities in learning achievement still exist. Although the percentage of students in the high category is greater in the control class, the overall distribution in the experimental class appears more balanced and more concentrated in the higher categories. This condition suggests that the learning process in the experimental class tends to better support students in achieving higher learning outcomes. Overall, both a higher level of achievement and a more even distribution of scores are observed in the experimental class compared to the control class.

This pattern may be explained by the learning approach applied in the experimental class, where students were actively involved in hands-on and minds-on activities. These activities provided opportunities for students to directly observe and analyze physical phenomena, thereby supporting deeper conceptual understanding. In contrast, students in the control class relied more on passive learning, which may have limited their ability to achieve higher cognitive levels. Furthermore, an analysis of students' cognitive learning outcomes was conducted based on cognitive levels (C1–C6), with the comparison of mean scores between the experimental and control classes presented in Figure 2.

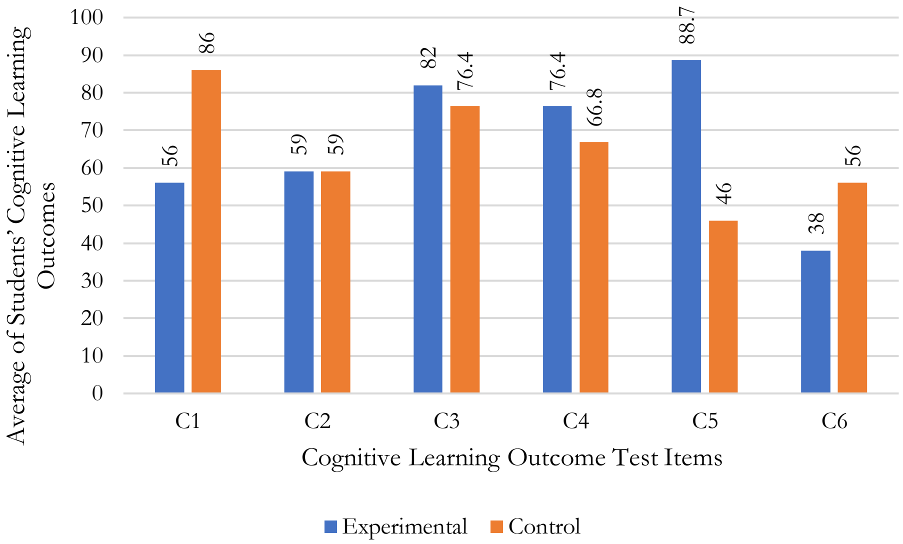

Figure 2. *Comparison of Students' Mean Scores Across Cognitive Levels (C1–C6)*

However, an important pattern can be observed in Figure 2. Although the experimental class shows higher mean scores across most cognitive levels, there are certain levels, particularly C1 (remembering) and C6 (creating), where the control class demonstrates higher performance. This finding is consistent with the item-level analysis, in which some test items also showed better performance in the control class. A similar pattern is reflected in Table 6, where the proportion of students in the "high" category is greater in the control class. These results indicate that, although the experimental class tends to perform better overall, the improvement is not uniformly distributed across all cognitive levels.

At the C1 level, the higher performance of the control class may be attributed to the characteristics of conventional instruction, which emphasizes direct explanation and repetition. Such approaches tend to better support memorization and recall of factual knowledge. At the C6 level, the slightly higher performance in the control class may be related to the limited number of test items representing this level, as well as the complexity of measuring creative thinking through multiple-choice questions. This suggests that the assessment of higher-order thinking skills, particularly creating, may not be fully captured by the instrument used in this study.

In contrast, the experimental class demonstrated more consistent performance at the intermediate and higher cognitive levels (C3–C5), which involve applying, analyzing, and evaluating concepts. These results are closely related to the learning activities implemented through experiential learning, where students were actively engaged in observing phenomena, conducting simple experiments, and solving problems connected to real-world situations using simple instructional media. Through these activities, students were encouraged not only to recall information but also to apply heat concepts in practical contexts, analyze experimental results, and evaluate relationships between physical phenomena and theoretical principles. Therefore, the statistical findings reflect the influence of learning experiences that emphasize active participation and contextual understanding. This indicates that experiential learning supported by simple instructional media provides meaningful learning experiences that contribute more effectively to the development of higher-order cognitive skills than to basic memorization processes.

5. Discussion

5.1. Interpretation of Findings

The findings of this study indicate that students in the experimental class, who were taught using the experiential learning model supported by simple instructional media, demonstrated a generally better tendency in cognitive learning outcomes compared to those in the control class. This suggests that learning through direct experience enables students to construct a more meaningful understanding of physics concepts, particularly on the topic of heat.

At the lower cognitive level the control class showed better performance. This finding indicates that conventional teacher-centered instruction, which emphasizes direct information delivery, tends to better support memorization. However, experiential learning does not primarily focus on memorization but rather on developing understanding through experience. This is consistent with Fauzi Fahmi et al., (2021), who state that experiential learning promotes meaningful learning and the development of scientific thinking skills. At the understanding level, both classes demonstrated relatively similar performance, suggesting that both instructional approaches are capable of facilitating basic conceptual comprehension (Sahlan et al., 2021).

More importantly, at higher cognitive levels, including applying, analyzing, and evaluating, students in the experimental class outperformed those in the control class. This indicates that experiential learning tends to better support the development of higher-order thinking skills. Through activities such as experimentation, reflection, and problem-solving, students are encouraged not only to understand concepts but also to apply, analyze, and evaluate them in different contexts. These findings support previous studies by Fegi et al. (2021) and Herlina. M et al. (2020), which highlight the effectiveness of experience-based learning in enhancing higher-order cognitive skills.

In the creating level, the control class showed slightly better performance. This may be due to the complexity of this cognitive level, which requires the ability to generate new ideas independently. In experiential learning, the focus is not only on cognitive outcomes but also on process skills and student engagement. Therefore, the development of creating ability may not be fully captured through cognitive test instruments alone. This is in line with Ruwaida (2019), who states that creating represents the highest level of cognition and requires comprehensive conceptual mastery. Overall, these findings indicate that experiential learning supported by simple media is particularly effective in enhancing students' higher-order thinking skills, while conventional learning may still play a role in supporting basic cognitive processes such as remembering. These findings reinforce the role of experiential learning as an effective approach for fostering deeper conceptual understanding and higher-order thinking in physics education.

In addition, this study offers a specific contribution by integrating experiential learning with simple instructional media in the context of heat concepts, which has been relatively underexplored in previous studies. Unlike prior research that tends to examine experiential learning or instructional media separately, this study demonstrates how their combination can support the development of students' cognitive abilities across different levels. This integration represents a practical and context-relevant approach, particularly for physics learning environments with limited laboratory facilities.

5.2. Implications

The results of this study have important implications for physics education, particularly in the teaching of abstract concepts such as heat. The findings suggest that the integration of experiential learning with simple instructional media can serve as a promising alternative instructional approach to improve students' cognitive learning outcomes. From a pedagogical perspective, this study highlights the importance of shifting from teacher-centered instruction to student-centered learning that emphasizes active participation, direct experience, and reflective thinking. The use of simple media enables teachers to implement meaningful learning experiences even in schools with limited resources, making this approach highly practical and scalable. This is particularly relevant in the context of global education, where the development of critical thinking and problem-solving skills has become a major priority.

Furthermore, this study contributes to the development of physics education by providing empirical evidence that experiential learning not only enhances conceptual understanding but also promotes higher-order thinking skills, which are essential competencies in 21st-century learning. The findings also suggest that integrating hands-on and minds-on activities can bridge the gap between theoretical knowledge and real-world phenomena. For future research, these findings open opportunities to explore the integration of experiential learning with other instructional approaches, as well as its application to different physics topics and educational levels.

These findings have broader implications for physics education, particularly in developing countries where access to laboratory facilities is often limited. The use of simple instructional media provides an accessible and cost-effective alternative for implementing experiential learning in resource-constrained classrooms. By promoting hands-on and minds-on learning, this approach supports the development of higher-order thinking skills, which are essential competencies in 21st-century learning and are emphasized in international education frameworks such as PISA and STEM education. Therefore, this approach may serve as a relevant strategy to support efforts in improving the quality and equity of physics education.

5.3. Limitation

Despite the positive findings, this study has several limitations that should be acknowledged. First, the study employed a quasi-experimental design with a limited sample size from a single school, which may affect the generalizability of the results. Future studies are recommended to involve a larger and more diverse sample to strengthen the external validity. Second, the measurement of cognitive learning outcomes was limited to a posttest, without incorporating a pretest. As a result, the improvement in students' learning outcomes could not be measured directly. Future research could employ a pretest-posttest design to provide a more comprehensive analysis of learning gains. Third, the assessment focused primarily on cognitive outcomes, while experiential learning also emphasizes affective and psychomotor aspects. Therefore, the full impact of the learning model may not be entirely captured in this study. Another limitation of this study lies in the distribution of cognitive outcomes across different levels, where certain results showed that the control class outperformed the experimental class, particularly at the C1 and C6 levels. This indicates that the impact of experiential learning may not be uniform across all cognitive domains. Additionally, the use of multiple-choice tests to assess higher-order thinking skills, especially at the creating level, may not fully capture students' actual abilities. Future studies are encouraged to include multiple dimensions of learning assessment. Lastly, the implementation of experiential learning requires sufficient time and careful classroom management, which may pose challenges for teachers. Further research is needed to explore strategies for optimizing its implementation in different classroom settings.

6. Conclusion

Based on the findings, the implementation of the experiential learning model supported by simple instructional media can improve students' cognitive learning outcomes on the topic of heat. This is indicated by the higher overall performance of students in the experimental class compared to the control class. In addition, the experimental class demonstrated a more balanced distribution of scores and a stronger tendency toward higher-order cognitive processes. These findings suggest that experiential learning supported by simple instructional media provides meaningful learning experiences that enhance students' understanding and engagement in physics learning.

Future research is recommended to examine the implementation of experiential learning across different physics topics and educational levels, as well as to integrate various types of instructional media. Furthermore, future studies are encouraged to investigate not only cognitive outcomes but also affective and psychomotor aspects in order to obtain a more comprehensive understanding of students' learning development.

Author Contributions

Yulianti Safhira: Conceptualization, methodology, data curation, formal analysis, writing of the original draft, review and editing. **Muhammad Syafii:** Conceptualization, methodology, review and editing, and supervision. **Naila Fauza:** Methodology, review and editing, and supervision. All authors have read and approved the final version of the manuscript.

Ethical Statement

This research was conducted within the context of regular classroom learning and falls under the category of educational research with minimal risk. Permission to conduct the study was obtained from SMAN 10 Pekanbaru through an official research permit issued by the Dean of Universitas Riau. Student participation was voluntary, and all participants were provided with information regarding the objectives, procedures, and benefits of the research. Consent was obtained from the students and the respective teacher.

Declaration of AI use

The authors used ChatGPT (OpenAI) to improve sentence clarity and readability in the original Indonesian draft. Finally, Grammarly was used to polish the English language (grammar, spelling, punctuation, and style). All AI-assisted outputs were reviewed and edited by the authors, who remain fully responsible for the accuracy, originality, and integrity of the final manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest, whether financial or non-financial, that could directly or indirectly influence the results of this study. All authors have reviewed and approved the content of the manuscript.

Supplementary Materials and Data Availability

The research instruments and summary of the research data used in this study are available and can be obtained from the corresponding author upon reasonable request. The shared data will be anonymized and adjusted in accordance with research ethics provisions.

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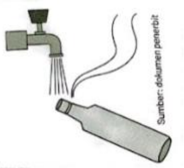
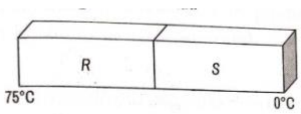
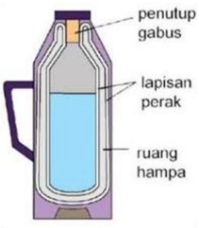
Appendix A. Research Instruments

Table 6. *Instrument for Assessing Cognitive Learning Outcomes*

No.	Indicators	Question Indicators	Question	Answer Key
1.	Remember (C1)	Students are able to recall the term used for the reference point in temperature scale determination (lower fixed point)	The freezing point of pure water at 1 atm pressure is defined as 0°C on the Celsius scale and 32°F on the Fahrenheit scale. This concept is known as... A. Latent Heat B. Upper Fixed Point C. Lower Fixed Point D. Specific Heat E. Koefisien Muai	C
2.	Apply (C3)	Students are able to convert temperature from Fahrenheit to absolute scale (Kelvin)	Romli measures the temperature of substance X. If measured using a Fahrenheit thermometer, the result is 312°F. What is the absolute temperature (Kelvin) of substance X….. A. 273 K B. 429 K C. 585 K D. 723 K E. 853 K	B
3.	Understand (C2)	Students are able to explain the relationship between metal expansion and the ease of opening a bottle cap after being exposed to hot water	Observe the following figure!  A tightly sealed metal bottle cap can be easily opened after being poured with hot water. This occurs because the coefficient of expansion of the bottle cap is… A. Smaller than the coefficient of expansion of the glass bottle neck B. Greater than the coefficient of expansion of the air inside the bottle C. Smaller than the coefficient of expansion of the air inside the bottle D. Smaller than the coefficient of expansion of the glass and water E. Greater than the coefficient of expansion of the glass bottle neck	E
4.	Apply (C3)	Students are able to determine the final length of a metal due to temperature change	A metal rod has a length of 10 m at 10°C. When heated to 110°C, its length becomes 10,04 m. Determine its length at 160°C……. A. 10,06 m	A

No.	Indicators	Question Indicators	Question	Answer Key
			B. 10,08 m C. 10,10 m D. 10,12 m E. 10,05 m	
5.	Analyze (C4)	Students are able to analyze and calculate the volume of fluid overflow due to expansion differences	A one liter container is made of a material with a linear expansion coefficient of $1.5 \times 10^{-5}/°C$. The container is filled with fluid ($\gamma = 1.45 \times 10^{-4}/°C$). If heated by 50°C, how much fluid overflows…. A. $5{,}0 \times 10^{-3}$ liter B. $6{,}5 \times 10^{-3}$ liter C. $7{,}0 \times 10^{-3}$ liter D. $8{,}0 \times 10^{-3}$ liter E. $9{,}2 \times 10^{-3}$ liter	A
6.	Evaluate (C5)	Students are able to evaluate and calculate the minimum gap in glass installation	An architect installs a glass panel (1 m × 1.5 m). What minimum gap should be provided if $\Delta T = 30°C$… ($\alpha = 6 \times 10^{-6}/°C$) A. 0,18 mm B. 0,27 mm C. 0,36 mm D. 0,45 mm E. 0,54 mm	B
7.	Remember (C1)	Students are able to define specific heat correctly	Which of the following statements best defines the specific heat capacity of a substance…. A. The total energy possessed by 1 kg of a substance at a certain temperature. B. The change in volume of a substance when heated until it reaches its boiling point. C. The amount of heat energy required to raise the temperature of 1 kg of a substance by 1°C. D. The rate of heat transfer through the substance. E. The amount of heat required to change the phase of a substance.	C
8.	Apply (C3)	Students are able to calculate the amount of heat released by water when it undergoes a decrease in temperature and changes phase into ice by applying the concepts of specific heat capacity and latent heat of fusion.	Water with a mass of 250 grams at a temperature of 10°C is to be turned into ice cubes. If the latent heat of fusion of ice is 80 cal/g and the specific heat capacity of water is 1 cal/g·°C, then the amount of heat released by the water is … A. 22,5 kkal B. 12,5 kkal C. 10,5 kkal D. 7,25 kkal E. 2,25 kkal	A
9.	Apply (C3)	Students are able to determine the specific heat capacity of a metal based on data on mass, initial temperature, final temperature, and the specific heat	A metal with a mass of 2 kg at a temperature of 56°C is placed into 1 kg of water at 20°C. After thermal equilibrium is reached, the final temperature of the mixture becomes 32°C. If the specific heat capacity of water is 1 cal/g·°C, then the specific heat capacity of the metal is … A. 0,15 kal/g·°C	B

No.	Indicators	Question Indicators	Question	Answer Key
		capacity of water by applying Black's Principle.	B. 0,25 kal/g·°C C. 0,50 kal/g·°C D. 1,25 kal/g·°C E. 1,50 kal/g·°C	
10.	Analyze (C4)	Students are able to analyze the heat exchange process in the mixing of ice and water to determine the final state of the mixture (whether the ice melts completely or only partially).	A total of 500 g of ice at -4°C is mixed with 600 g of water at 55°C. If the specific heat capacity of ice is 0.5 cal/g·°C and the latent heat of fusion of ice is 80 cal/g, then the final state of the mixture is … A. All of the ice melts and the final temperature of the mixture is 5°C B. All of the ice melts and the final temperature of the mixture is 0°C C. Part of the ice melts and the final temperature of the mixture is 0°C D. Part of the ice melts and the final temperature of the mixture is -4°C E. The ice does not melt at all and the final temperature of the mixture is -4°C	C
11.	Analyze (C4)	Students are able to analyze the heat exchange between water and ice to determine the mass ratio based on the condition that only part of the ice melts.	In a container whose mass is neglected, water at 30°C is mixed with ice at -10°C. After thermal equilibrium is reached, 25% of the ice mass melts. If the melting point of ice is 0°C, determine the ratio of the initial mass of water to the initial mass of ice….. A. 1 : 4 B. 1 : 2 C. 1 : 1 D. 5 : 6 E. 6 : 5	D
12.	Evaluate (C5)	Students are able to evaluate the properties of materials with equal masses but different specific heat capacities.	Two materials, P and Q, have the same mass. Material P has a high specific heat capacity (cP), while Material Q has a low specific heat capacity (cQ). Which of the following statements is the most accurate regarding the comparison of the properties of the two materials…. A. Material Q heats up more slowly than Material P when given the same amount of heat. B. Material P is more suitable for making an electric iron because it heats up quickly. C. Material Q will reach a higher temperature than Material P when given the same amount of heat. D. Material P requires less heat than Material Q to increase its temperature by 1°C. E. Material Q is more effective as a cooling material because it absorbs heat quickly.	C
13.	Analyze (C4)	Students are able to analyze the equilibrium of the heat flow rate to determine the temperature at the boundary surface	Observe the following figure!  Two metal rods, R and S, have the same length and cross-sectional area, but are made of different types of	D

No.	Indicators	Question Indicators	Question	Answer Key
		between two metal rods.	metal. They are connected to each other as shown in the figure. If the thermal conductivity coefficient of rod R is twice that of rod S, then the temperature at the boundary surface between rods R and S is … A. 75^{o}C B. 60^{o}C C. 55^{o}C D. 50^{o}C E. 45^{o}C	
14.	Evaluate (C5)	Students are able to select the appropriate experimental procedure to test the hypothesis of the relationship between mass and heating time	You want to test the following hypothesis: The greater the mass of a substance (of the same type), the longer the time required to reach its boiling point. The most appropriate experimental design procedure to prove this hypothesis is... A. Heating 100 g of water and 100 g of oil using the same heating power. B. Heating 100 g of water and 200 g of water using the same heating power and identical containers. C. Heating 100 g of water with 100 W power and 200 g of water with 200 W power. D. Measuring the temperature of the same amount of water in two different containers after 5 minutes. E. Using different calorimeters for each mass of water.	B
15.	Apply (C3)	Students are able to calculate the rate of heat transfer by conduction due to changes in the length of a metal	Heat flows through a 50 cm metal rod at a rate of 2,000 J/s. If the metal rod is cut into two equal lengths, and the temperature difference between the two ends of each piece remains the same, then the rate of heat transfer through one of the metal pieces is.... A. 1.500 J/s B. 2.000 J/s C. 4.000 J/s D. 6.000 J/s E. 8.000 J/s	C
16.	Analyze (C4)	Students are able to analyze the function of a shiny surface in a thermos in reducing heat radiation.	Observe the following part of a hot water thermos!  The inner wall of the thermos is made shiny. Which of the following best describes the main function of the shiny wall…. A. To accelerate heat transfer through conduction. B. To accelerate heat transfer through air convection. C. To reflect heat radiation back inside, thereby reducing heat loss through radiation. D. To convert heat into mechanical energy. E. To inhibit heat transfer through conduction between the walls	C

No.	Indicators	Question Indicators	Question	Answer Key
17.	Create (C6)	Students are able to design optimal cooking equipment based on the law of heat conduction rate ($H = kA\Delta T/L$)	An engineer wants to design cooking equipment that can transfer heat as quickly as possible from the flame to the food (high conduction efficiency). Based on the law of heat conduction rate ($H = kA\Delta T/L$), the most appropriate material design is to use..... A. A pan with a large surface area, thick thickness, and low thermal conductivity. B. A pan with a small surface area, thin thickness, and high thermal conductivity. C. A pan with a large surface area, thick thickness, and high thermal conductivity. D. A pan with a large surface area, thin thickness, and high thermal conductivity. E. A pan with a small surface area, thin thickness, and low thermal conductivity.	D

Appendix B. Instruments Validation

The validation of the research instrument was conducted to ensure that the cognitive learning outcomes test accurately measured students' cognitive abilities on the topic of heat. Content validity was assessed by expert validators based on four main aspects: (A) the alignment of test items with the learning objectives, (B) the accuracy and appropriateness of the scientific concepts, (C) the suitability of the items in representing the cognitive indicators (C1–C6), and (D) the clarity of language and writing. The assessment was conducted by assigning scores in the provided assessment aspect columns using a five-point Likert scale: 1 (poor), 2 (less good), 3 (fairly good), 4 (good), and 5 (very good). The following presents the results of the content validation of the cognitive learning outcomes instrument on the topic of heat.

Table 7. *Cognitive Learning Outcomes Instrument Validation Results*

Question No.	Validator 1				Validator 2			
	Aspect				Aspect			
	A	B	C	D	A	B	C	D
1	5	5	5	4	5	5	5	4
2	5	5	5	4	5	5	5	4
3	5	4	5	3	5	4	5	4
4	5	5	5	4	5	5	5	4
5	5	4	5	3	5	4	5	4
6	5	5	5	4	5	5	5	4
7	5	5	5	4	5	5	5	4
8	5	4	5	3	5	5	5	4
9	5	4	5	3	5	4	5	3
10	5	5	5	4	5	5	5	4
11	5	4	5	3	5	4	5	3
12	5	4	5	3	5	4	5	3
13	5	5	5	4	5	5	5	4
14	5	4	5	3	5	4	5	3
15	5	5	5	4	5	5	5	4
16	5	5	5	4	5	5	5	4
17	5	5	5	4	5	5	5	4

The ratings assigned by the expert validators for each assessment aspect were further analyzed using Aiken's V coefficient to evaluate the content validity of each item in the cognitive learning outcomes instrument on the topic of heat. The results of the analysis are presented in Table 9.

Table 8. *Content Validity Results of Cognitive Learning Outcomes Test Items on the Topic of Heat Using Aiken's V*

Question No.	Aiken's V	Category
1	0.938	Highly Valid
2	0.938	Highly Valid
3	0.844	Highly Valid
4	0.938	Highly Valid
5	0.844	Highly Valid
6	0.938	Highly Valid
7	0.938	Highly Valid
8	0.875	Highly Valid
9	0.813	Highly Valid
10	0.938	Highly Valid
11	0.813	Highly Valid
12	0.813	Highly Valid
13	0.938	Highly Valid
14	0.813	Highly Valid
15	0.938	Highly Valid
16	0.938	Highly Valid
17	0.938	Highly Valid
Average Aiken's V	**0.893**	**Highly Valid**

The instrument utilized a five-point rating scale ($c = 5$) and was assessed by two expert validators. The content validity criteria were defined such that $V \geq 0.80$ represents high validity (highly valid), while $0.60 \leq V < 0.80$ represents acceptable validity (valid). The analysis of content validity for the cognitive learning outcomes instrument on the topic of heat was conducted using Aiken's V index based on expert judgments across four assessment aspects. The results showed that Aiken's V values ranged from 0.813 to 0.938, with an average value of 0.893. All items met the criteria of highly valid, indicating that the instrument is appropriate for use in this research.