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Development Of Practical Equipment For Heat Material For Grade VII Students Of Mts Hidayatul Qomariah

Pengembangan Alat Praktis untuk Materi Pemanasan bagi Siswa Kelas VII MTs Hidayatul Qomariah

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ABSTRACT

Limited laboratory infrastructure in Islamic Junior High Schools (MTs) is a significant structural obstacle in implementing practical-based science learning. This study aims to develop simple, economical, and effective heat material practicum devices to improve the conceptual understanding of seventh-grade students at MTs Hidayatul Qomariah, Bengkulu City. The method used is research and development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The devices developed include a recycled material-based temperature measuring device, Student Worksheets (LKPD), and teacher practicum guides. Product feasibility was assessed through validation by material experts, media experts, and language experts, while its effectiveness was measured through pre-tests and post-tests on 28 seventh-grade students. The validation results showed a very high level of feasibility in all aspects: material experts (88.33%), media experts (98.33%), and language experts (89.58%). Student responses to the practicum devices reached 91.51% in the very good category. The effectiveness of learning is proven by a significant increase in the average learning outcomes from 59.29 (pre-test) to 86.89 (post-test), with an N-Gain value of 0.68 (medium category approaching high). The paired t-test produced a t-value of 11.692 which is statistically significant at the α level of 0.05 (t-table = 2.052). This finding confirms that the recycled material-based heat material practicum device is a theoretically feasible and empirically effective alternative for science learning, especially for schools operating with limited laboratory facilities.

***Keywords:** Laboratory Equipment; Heat Material; ADDIE Model; Student Learning Outcomes; Science Learning*

ABSTRAK

Keterbatasan infrastruktur laboratorium di SMP Islam (SMP) merupakan hambatan struktural yang signifikan dalam penerapan pembelajaran sains berbasis praktik. Penelitian ini bertujuan untuk mengembangkan perangkat praktikum bahan panas yang sederhana, ekonomis, dan efektif untuk meningkatkan pemahaman konseptual siswa kelas tujuh di SMP Hidayatul Qomariah, Kota Bengkulu. Metode yang digunakan adalah penelitian dan pengembangan (R&D) dengan model ADDIE (Analisis, Desain, Pengembangan, Implementasi, Evaluasi). Perangkat yang dikembangkan meliputi alat pengukur suhu berbahan daur ulang, Lembar Kerja Siswa (LKPD), dan panduan praktikum guru. Kelayakan produk dinilai melalui validasi oleh ahli material, ahli media, dan ahli bahasa, sedangkan efektivitasnya diukur melalui tes pra dan pasca pada 28 siswa kelas tujuh. Hasil validasi menunjukkan tingkat kelayakan yang sangat tinggi dalam semua aspek: ahli material (88,33%), ahli media (98,33%), dan ahli bahasa (89,58%). Respons siswa terhadap perangkat praktikum mencapai 91,51%, yang dikategorikan sangat baik. Efektivitas proses pembelajaran ditunjukkan oleh peningkatan signifikan pada hasil belajar rata-rata dari 59,29 (pra-uji) menjadi 86,89 (pasca-uji), dengan nilai N-Gain sebesar 0,68 (sedang mendekati tinggi). Uji t berpasangan menghasilkan nilai t sebesar 11,692, yang secara statistik signifikan pada tingkat α 0,05 (t-tabel = 2,052). Temuan ini menegaskan bahwa perangkat laboratorium bahan panas berbahan daur ulang

merupakan alternatif yang secara teoritis layak dan secara empiris efektif untuk pembelajaran sains, terutama untuk sekolah yang beroperasi dengan Fasilitas Laboratorium Terbatas.
Kata Kunci: Peralatan Laboratorium; Bahan Panas; Model Addie; Hasil Belajar Siswa; Pembelajaran Sains

1. Introduction

Science learning at the junior high school level has a strategic role in shaping students' scientific literacy as a foundation for scientific thinking skills. Within this framework, practical activities occupy a central position as a bridge between conceptual understanding and empirical experience, allowing students to actively construct knowledge through a cycle of observation, experimentation, and critical reflection. The concept of heat, as one of the fundamental topics in the seventh grade science curriculum, inherently requires a direct, experiential approach to be understood deeply and meaningfully. Within the framework of Islamic epistemology, observation of natural phenomena is seen as a cognitive instrument in understanding the majesty of Allah SWT, as the phenomenon of heat is implied in QS. Al-Qāri'ah [101]: 10–11 as an integral part of His creation (Ulama, 2019) .

However, the implementation of lab-based learning in Islamic Junior High Schools (MTs) still faces significant structural barriers. A preliminary study at MTs Hidayatul Qomariah in Bengkulu City identified critical limitations in the form of deficient science laboratory infrastructure, inadequate lab tools and materials, and limited learning time. These conditions encourage the dominance of a transmissive approach in the learning process, which in turn reduces students' opportunities for authentic and contextual hands-on learning experiences. These findings align with reports from various empirical studies documenting similar phenomena in religious-based educational institutions in Indonesia.

Previous empirical studies confirm the urgency of this issue from various perspectives. Safitri et al., (2025) emphasized that teaching aids play a determinative role in clarifying abstract concepts while increasing student learning motivation, although their use in religious-based institutions is still limited to certain material coverage. Bili et al., (2024) demonstrated a significant positive correlation between the use of laboratory equipment and improved student learning outcomes in temperature and heat materials, but identified accessibility and availability of equipment as the main obstacles to implementation. Meanwhile, Bhakti et al., (2025) developed an assessment instrument based on higher-order thinking skills in physics learning, although it did not address the aspect of providing physical laboratory equipment that is responsive to limited facilities.

Other studies also strengthen the urgency of this research. Payu et al., (2023) reported that guided inquiry-based learning tools received a very positive response from teachers and students in the context of temperature and heat materials, but identified the need for improvements in terms of accessibility of user instructions for schools with limited resources. Nurnaifah, (2024) showed that the effectiveness of curriculum implementation directly depends on the availability of integrated and standardized learning tools. Akuba et al., (2024) proved that the variety of use of practical tools contributed significantly to increasing student active engagement in science learning.

The development of learning technologies, including virtual laboratories and the integration of STEM approaches, has presented a promising alternative to address the limitations of physical facilities (Achuthan et al., (2021) ; Rahmi et al., (2022) . However, these approaches require the availability of additional technological infrastructure that is not always available in schools with limited resources, and are not yet fully capable of providing optimal hands-on experiences for students. This gap indicates an urgent need for the development of physical practicum tools that are simple, contextual, and adaptive to real-world conditions, including the availability of local materials for tool construction.

Referring to this gap, this study was designed to develop a practical tool for heat material through the ADDIE model framework that includes three main components: a simple temperature measuring tool based on recycled materials, Student Worksheets (LKPD), and teacher practical guides. This development is oriented towards three strategic dimensions: (1) affordability and ease of replication using locally available materials, (2) suitability with the basic competencies of the seventh grade curriculum, and (3) effectiveness in improving students' conceptual understanding through direct learning experiences. Thus, this study is expected to contribute to improving the quality of science learning at the MTs level while providing practical solutions to the problem of limited laboratory facilities which is still a systemic challenge in many schools.

2. Research methods

This study uses a research and development (R&D) approach with the ADDIE model as the procedural framework for product development. The ADDIE model consists of five cyclical and systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected based on its ability to provide a structured development procedure with formative evaluation mechanisms at each phase, thus allowing for continuous improvement before the product is fully implemented (Anafi et al., (2021) ; Rachma et al., (2023) . This approach is considered most appropriate for the context of developing practical tools that require gradual validation and iterative refinement before use in authentic learning.

The research was conducted at MTs Hidayatul Qomariah, Bengkulu City, involving 28 seventh-grade students as research subjects. The location was chosen based on two main considerations: first, the deficiency of science laboratory infrastructure which directly impacted the low intensity of practical activities; and second, the identified empirical need for simple practical equipment that can be operated under conditions of limited facilities, especially for heat material.

Chronologically, the research is divided into three main phases. The first phase consists of initial observation and needs assessment, conducted from October 2024 to January 2025. This phase aims to map the conditions of science learning and identify gaps between learning needs and available resources. The second phase includes product validation by experts, conducted in August 2025, involving comprehensive assessments by material experts, media experts, and linguists to ensure the appropriateness of the content, design quality, and readability of the device. The third phase is a field trial, conducted from January to February 2026, aimed at evaluating the effectiveness of the device in an authentic learning context.

The data collection instruments included: (1) an expert validation sheet to assess the product's feasibility from the material, media, and language aspects using a four-level Likert scale; (2) a student response questionnaire consisting of 10 closed-ended statements with a four-level Likert scale; and (3) a multiple-choice and descriptive learning outcome test instrument used in the pre-test and post-test. All instruments underwent a conceptual review process to ensure the suitability of the items with the indicators being measured.

Data analysis was carried out quantitatively with the following procedures. First, product feasibility was calculated using the percentage formula (P = score obtained / maximum score × 100%) with interpretation criteria: ≤ 25% (not feasible), 26–50% (less feasible), 51–75% (quite feasible), and 76–100% (very feasible). Second, product effectiveness was measured using the normalized N-Gain value based on the Hake formula: $g = (S_{post} - S_{p} \angle {}_{e}) / (S_{maks} - S_{p} \angle {}_{e})$, with categories: $g \geq 0.70$ (high), $0.30 \leq g < 0.70$ (moderate), and $g < 0.30$ (low). Third, the significance of the difference between the pre-test and post-test results was tested using a paired samples t-test at a significance level of $\alpha = 0.05$ with the help of statistical software.

3. Results and Discussion

1. Research result

This research resulted in a heat material practicum kit developed through the five stages of the ADDIE model: analysis, design, development, implementation, and evaluation. The final product consists of three integrated components: a simple temperature measuring practicum kit based on recycled materials (used plastic bottles, colored water, and an analog thermometer), Student Worksheets (LKPD), and a practicum guide for teachers. The development of this kit was motivated by the dominance of theoretical approaches in science learning at MTs Hidayatul Qomariah which systematically limits students' direct learning experiences.

a. Needs Analysis

The results of a preliminary study indicate that the learning of heat material in class VII of MTs Hidayatul Qomariah is not supported by adequate practicum equipment. Teachers tend to rely on lecture and discussion methods as the main learning strategies, so that students do not get direct experimental-based learning experiences. This condition has an impact on low student active involvement and limited conceptual understanding of heat material. In addition, limited laboratory facilities are a structural factor that hinders the implementation of regular practicum activities. Based on the results of the needs analysis, five criteria were determined for the design of the developed practicum equipment: (1) easy to operate by students and teachers without special technical skills; (2) using simple and economical materials that are easily obtained locally; (3) meeting safety standards in learning activities; (4) supporting the implementation of experimental activities directly in the classroom; and (5) equipped with LKPD and structured practicum guides .

b. Product Design and Development

The design phase resulted in a conceptual design for a simple temperature measuring practicum tool that utilizes a used plastic bottle as a container, colored water as a visual medium, and an analog thermometer as a measuring component. This tool is designed to facilitate students in observing temperature changes directly through experimental activities that can be carried out in a regular classroom. The developed LKPD contains: (a) measurable and directed learning objectives; (b) a list of tools and materials; (c) systematic work procedures; (d) a structured observation table; and (e) tiered analysis questions that encourage students' critical thinking skills. Meanwhile, a teacher's guide was developed to provide comprehensive technical and pedagogical directions, including steps for implementing the practicum, elaboration of the heat concept, and a rubric for assessing science process skills. The following is a picture of the developed device:

Figure a. Student Worksheet (LKPD)

Figure b. Practical Guide

Figure c. Practical Tools

Figure 1. Developed Practical Equipment

c. Product Eligibility

1). Validation by Material Experts

Validation by material experts was conducted to assess the suitability of the contents of the practical equipment with the basic competencies and learning objectives of the heat material for grade VII. The validation results are presented in Table 1.

Table 1. Results of Material Expert Validation

Assessment Aspects	Max Score	Score Obtained	Percentage	Category
Eligibility of LKPD Content	20	18	90.00%	Very Worthy
Eligibility of Guide Materials	40	35	87.50%	Very Worthy
Total	**60**	**53**	**88.33%**	**Very Worthy**

Based on Table 1, the practical equipment obtained an aggregate feasibility score of 88.33%, categorized as very feasible. The feasibility of the LKPD content reached 90.00%, while the feasibility of the teacher's guide material obtained 87.50%. The validator provided several recommendations for improvement related to the systematic presentation of the material, the clarity of the formulation of learning objectives, and the simplification of work procedures. All recommendations were followed up through careful revisions before the product entered the implementation phase.

2). Media Expert Validation

Media expert validation was conducted to assess the design quality, functionality, and usability of the developed practical tools. The results of the media expert validation are shown in Table 2.

Table 2. Media Expert Validation Results

Assessment Aspects	Max Score	Score Obtained	Percentage	Category
Visual Display	20	19	95.00%	Very Worthy
Tool Design	20	20	100.00%	Very Worthy
Media Usability	20	20	100.00%	Very Worthy
Total	**60**	**59**	**98.33%**	**Very Worthy**

Table 2 shows that the practical tools obtained the highest feasibility score among all validation categories, namely 98.33% in the very feasible category. The tool design and media usability aspects each obtained a perfect score (100.00%), while the visual appearance aspect reached 95.00%. Media experts stated that the developed practical, safe, and appropriate design for use by seventh-grade students in the classroom learning context.

3). Validation by Linguists

The validation by linguists aimed to assess the readability and appropriateness of language use in the LKPD and practical guides with the cognitive development characteristics of seventh-grade students. The validation results are presented in Table 3.

Table 3. Results of Validation by Linguists

Assessment Aspects	Max Score	Score Obtained	Percentage	Category
Linguistics	28	24	85.71%	Very Worthy
Legibility	20	19	95.00%	Very Worthy
Total	**48**	**43**	**89.58%**	**Very Worthy**

The validation results from the linguists showed a feasibility score of 89.58%, categorized as very feasible. The readability aspect achieved a score of 95.00%, indicating that the language used in the practical tools was easy for students to understand. The linguistic aspect achieved a score of 85.71%, with suggestions for improvement related to the consistent use of technical terms and adjusting sentence complexity to the level of understanding of seventh-grade students.

d. Student Response

Student responses were obtained through a closed questionnaire from 28 seventh-grade students after the field trial. The response results are presented in Table 4.

Table 4. Student Response Results

Number of Students	Number of Statements	Maximum Score	Score Obtained	Percentage	Category
28	10	1120	1025	91.51%	Very good

The data in Table 4 shows that the lab equipment received a very positive response from students with a percentage of 91.51% in the very good category. This high percentage of responses indicates that the lab equipment was able to increase student interest, involvement, and confidence in carrying out experimental activities. Students generally stated that the lab equipment was easy to operate, the instructions in the LKPD were easy to follow, and the lab activities helped them understand the concept of heat more concretely than the lecture method.

e. Product Effectiveness

The effectiveness of the practical tools was evaluated through a comparative analysis of pre-test and post-test results. A summary of descriptive statistics of student learning outcomes is presented in Table 5.

Table 5. Summary of Statistics of Pre-test and Post-test Learning Outcomes

Description	Minimum Value	Maximum Value	Average	Elementary School
Pre-test	35	80	59.29	12.37
Post-test	65	100	86.89	9.24
N-Gain	—	—	0.68	—

The data in Table 5 shows a substantial increase in the average student learning outcomes from 59.29 (pre-test) to 86.89 (post-test), with an average difference of 27.61. The N-Gain value of 0.68 is in the moderate category approaching high, indicating the effectiveness of the practicum device in improving students' conceptual understanding of heat material. To test the statistical significance of this difference, a paired t-test was conducted with the results presented in Table 6.

Table 6. Paired t-Test Results Pre-test – Post-test

Variables	Mean	Elementary School	t count	t table	Information
Pre-test – Post-test	27.61	12.49	11,692	2,052	Significant

The results of the paired t-test produced a value of t_h^{ITUnG} = 11.692, which significantly exceeded the value of t_{tapel} = 2.052 at the α level = 0.05 with 27 degrees of freedom. Thus, H_0 was rejected and it can be concluded that there is a statistically significant difference between the results of the students' pre-test and post-test, which confirms the effectiveness of the heat material practicum device in improving the learning outcomes of class VII students of MTs Hidayatul Qomariah.

2. Discussion

a. Design of Practical Equipment for Heat Material

The development of the heat practicum equipment in this study was based on the urgent need to address the limitations of science learning, which is still dominated by the transmissive approach at MTs Hidayatul Qomariah. The resulting equipment, consisting of a recycled-material temperature measuring device, student worksheets (LKPD), and a teacher's guide, was designed as an integrated, experiment-based learning system. This design not only oriented towards the technical and functional aspects of the equipment but also considered pedagogical suitability, the characteristics of seventh-grade students' cognitive development, and the context of limited school facilities.

Theoretically, the design of this device is based on the principles of constructivism, which emphasize that knowledge is actively constructed by students through direct interaction with the learning environment and empirical experience. In the context of science learning, this approach means that a strong conceptual understanding can only be formed when students are actively involved in the process of observation, experimentation, and reflection on the natural phenomena being studied. The use of simple materials such as used plastic bottles, colored water, and analog thermometers as the main components of the practicum tools strategically eliminates accessibility barriers, while emphasizing that the quality of the learning experience is not determined by the luxury of equipment, but by the accuracy of its pedagogical design.

The development of student worksheets (LKPD) as a supporting component significantly contributes to structuring students' learning experiences during experimental activities. By including systematic work procedures, structured observation tables, and tiered analysis questions, LKPD facilitates students not only to conduct experiments procedurally but also to develop essential science process skills including observation, measurement, data interpretation, and conclusion drawing. This structure aligns with the characteristics of the guided inquiry approach, which has been proven effective in improving students' conceptual understanding and science process skills in various learning contexts (Payu et al., 2023) . Meanwhile, the teacher's guide serves as a supporting instrument that provides comprehensive technical and pedagogical direction, enabling teachers to manage practicum activities in a more structured and effective manner even without extensive experience in experiment-based learning.

The integration of these three components—practical tools, student worksheets (LKPD), and teacher guides—in a single learning toolkit represents a holistic and contextual approach. This configuration ensures that the entire practicum-based learning ecosystem is comprehensively facilitated, from equipment preparation and experiment implementation to observational data documentation, through to analysis and conclusion drawing. These findings reinforce the proposition that the effectiveness of practicum-based learning is not solely determined by the sophistication of the equipment used, but rather by the quality of integration between components of the learning toolkit, which supports active and meaningful student engagement in each phase of the experiment.

b. Suitability of Practical Equipment

The overall expert validation results confirmed that the developed heat material practicum device met very high feasibility standards. The validation scores from material experts (88.33%), media experts (98.33%), and language experts (89.58%) were consistently in the very feasibility category, indicating that the device simultaneously met quality requirements from the content, design, and communication dimensions.

The expert validation score of 88.33% indicates that the practicum equipment is substantially aligned with the core competencies of the curriculum and the learning objectives of the heat material for grade VII. The systematic presentation of the material in the LKPD is considered capable of supporting a structured, experiment-based learning process. However, recommendations for improvement related to the clarity of learning objectives and the details of the work procedures emphasize the importance of an iterative validation process in the development of ADDIE-based equipment. This validator feedback-based improvement process fundamentally improves the quality of the final product and reflects the superiority of the cyclical development approach over the linear approach.

The very high validation value of media experts (98.33%) indicates the success of the lab equipment design in meeting the criteria of practicality, safety, and suitability to user characteristics. Obtaining a perfect score in the aspects of tool design and media usability underscores that simple lab equipment based on recycled materials can achieve quality standards comparable to conventional laboratory equipment, as long as it is designed with appropriate learning design principles in mind. This finding has important implications for schools with limited budgets for laboratory equipment procurement, as it demonstrates the viability of an approach utilizing locally available materials that is easily and economically available.

Validation by linguists showed a feasibility score of 89.58%, with a readability rating of 95.00%. This indicates that the language used in the student worksheets and teacher guides has been effectively adapted to the cognitive and linguistic developmental levels of seventh-grade students. High readability is a critical factor in the successful implementation of the practicum tools, as unclear instructions can hinder the implementation of experiments and create misconceptions that are counterproductive to learning objectives.

These validation findings were reinforced by responses from science teachers who stated that the lab kits were easy to use, had clear instructions, and could be implemented without the need for specialized laboratory facilities. This statement validated the practicality of the kits in a real-world context beyond normative expert judgment and confirmed their relevance as an authentic and applicable learning solution. These positive teacher responses also indicated the potential for wider adoption in other schools with similar facilities.

The student response of 91.51% in the excellent category further strengthens the empirical evidence of the device's feasibility. The high level of student appreciation for the practicum device reflects the suitability between the device's design and their expectations and learning needs. The fact that students responded enthusiastically to simple material-based practicum activities demonstrates that student learning motivation is not solely determined by the device's technological sophistication, but rather by the relevance and hands-on experience offered in the learning process. This finding is in line with research by Safitri et al., (2025) which confirmed the significant role of the use of concrete teaching aids in increasing science students' motivation and learning engagement.

c. Effectiveness of Practical Equipment

The effectiveness of the lab equipment was comprehensively evaluated through three complementary indicators: the average increase in learning outcomes, the normalized N-Gain value, and statistical significance through a paired t-test. These three indicators consistently provided converging evidence regarding the equipment's effectiveness in improving students' conceptual understanding of heat.

The increase in the average learning outcome from 59.29 (pre-test) to 86.89 (post-test) with a difference of 27.61 points indicates a substantial learning impact from the use of the lab equipment. More significantly, the lower standard deviation in the post-test (9.24) compared to the pre-test (12.37) indicates that the use of the lab equipment not only increased the average learning outcome, but also contributed to a more even distribution of understanding among students. This phenomenon indicates that the experiment-based learning approach has a beneficial homogenizing effect, especially for students who previously had difficulty understanding concepts through an abstract approach.

An N-Gain value of 0.68, which is in the moderate-to-high category, indicates substantial device effectiveness. This value means that on average, students successfully mastered 68% of the material that had not been mastered before learning using the practicum device. This moderate-to-high category is consistent with the findings of various studies on the development of simple practicum devices in the context of science education in junior high schools, which reported an N-Gain range of 0.50–0.75 for experiment-based learning interventions (Bili et al., 2024; Akuba et al., 2024). The N-Gain value obtained in this study indicates that simple practicum devices based on recycled materials can provide learning impacts comparable to more complex and expensive devices.

The paired t-test results ($t_{h}^{ITUnG} = 11.692 > t_{tapel} = 2.052$; $\alpha = 0.05$) statistically confirmed that the difference in pre-test and post-test results was not a chance artifact, but rather reflected the real impact of the learning intervention using the developed practicum tools. The t_h^{ITUnG} value that far exceeded the t_{tapel} threshold indicated a large effect size of the intervention, which implied that this practicum tool had a strong capacity to produce meaningful and measurable learning changes.

This significant improvement in learning outcomes can be analyzed through several interacting learning mechanisms. First, the experimental activities directly stimulate students' multisensory engagement through visual observation of color changes in temperature indicators, thermometer readings, and data recording, which collectively strengthen memory traces and conceptual understanding. Second, the process of following structured student worksheet procedures encourages students to develop sequential and systematic thinking, which are essential components of science process skills. Third, the analytical questions in the student worksheet encourage students to connect the empirical data collected with the theoretical concepts learned, so that learning does not stop at the procedural level but reaches a deeper level of conceptual understanding. Fourth, group dynamics during the practicum facilitate collaborative and discursive learning that further strengthens understanding through the articulation and negotiation of meaning among students.

The findings of this study consistently align with the conclusions of various previous empirical studies. Bili et al.'s (2024) research demonstrated a strong positive correlation between the use of innovative learning media and improved student learning outcomes on temperature and heat. Achuthan et al. (2021) identified interactivity and hands-on experience in experimental activities as key predictors of successful science learning. Rahmi et al. (2022) demonstrated that an experiment-based approach consistently yielded deeper conceptual understanding than conventional passive learning approaches. The consistency of these research findings with existing literature strengthens the validity and reliability of the results.

The sustainability of the device's use also needs to be considered. The low production costs and availability of materials in the local market make it highly replicable by other schools in similar situations. Teachers can create the lab equipment themselves without requiring specialized technical expertise, significantly minimizing implementation barriers. This characteristic is a competitive advantage that distinguishes this device from virtual laboratory or STEM approaches that require larger investments in technological infrastructure.

This study is not without limitations that need to be acknowledged. First, the study subjects were limited to 28 students in one class at one school, limiting the generalizability of the findings. A larger and more diverse sample is needed to confirm these findings more comprehensively. Second, the pre-test–post-test design without a control group used in this study did not allow for full control of confounding variables that could influence learning outcomes. Third, this study only measured cognitive learning outcomes through multiple-choice and essay tests, without assessing the dimensions of science process skills and affective skills, which are also important targets of practicum-based learning. Further research using quasi-experimental designs and multidimensional measurements is recommended to address these limitations.

4. Conclusion

This research successfully developed a practical tool for heat material consisting of a simple temperature measuring device based on recycled materials, Student Worksheets (LKPD), and teacher practical guides through the implementation of the ADDIE model. The developed tool was declared very feasible based on comprehensive validation by material experts (88.33%), media experts (98.33%), and language experts (89.58%), and received a very positive response from students (91.51%). The effectiveness of the tool was empirically confirmed through a significant increase in the average student learning outcomes from 59.29 to 86.89, with an N-Gain value of 0.68 (medium category approaching high) and statistically significant paired t-test results (t_h^{ITUnG} = 11.692 > t_{tapel} = 2.052; α = 0.05). These findings confirm that simple and economical recycled material-based lab equipment can serve as an effective science learning alternative for schools with limited laboratory facilities, while also contributing to the equitable distribution of the quality of science learning experiences in the madrasah education context.

Suggestion

Based on the findings and limitations of this study, several recommendations are proposed for further research and practice. First, the developed lab kits can be readily adopted as alternative science learning media in schools with similar facilities, given their ease of replication and low production costs. Second, further research is recommended to pilot the kits on a larger scale with a quasi-experimental design involving a control group, in order to generate stronger and more generalizable evidence of effectiveness. Third, the development of similar lab kits needs to be expanded to other science materials with comparable characteristics and implementation challenges, such as electricity, optics, and ecosystems. Fourth, future research is also recommended to integrate assessments of science process skills and affective dimensions in evaluating the effectiveness of lab-based learning.

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