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The Use of Cassy Lab in Calorimeter Experiment with Different Material as Learning Media

AJ Suharli[1*], Isnania[2]

[1]Physics Education, Universitas Jambi, Jambi, Indonesia
[2] Elementary School Teacher Education, Universitas Jambi, Jambi, Indonesia
**Corresponding author: suharliaj@unja.ac.id*

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Abstract: *This study examined the effectiveness of Cassy Lab–based practicum activities in improving students' understanding of temperature and heat concepts. A quantitative quasi-experimental method with a non-equivalent control group design was applied to 30 second-semester Physics Education students at Jambi University. Data were collected using pre-test and post-test instruments adapted from the Thermal and Transport Concept Inventory (TTCI). Analysis using IBM SPSS Statistics 26 included normality, N-gain, and independent t-test. Results showed that both groups improved, but the Cassy Lab group achieved a higher N-gain. The T-test indicated a significant difference between groups. These findings suggest that Cassy Lab–based practicum is effective in enhancing conceptual understanding and serves as an innovative technology-based learning medium. Further research should explore its impact on scientific process skills, critical thinking, and motivation with broader samples.*

Abstrak: Penelitian ini mengkaji efektivitas kegiatan praktikum berbasis Laboratorium Cassy dalam meningkatkan pemahaman siswa tentang konsep suhu dan panas. Metode kuasi-eksperimental kuantitatif dengan desain kelompok kontrol non-ekuivalen diterapkan pada 30 mahasiswa Pendidikan Fisika semester dua di Universitas Jambi. Data dikumpulkan menggunakan instrumen *pra*-uji dan *pasca*-uji yang diadaptasi dari Inventaris Konsep Termal dan Transportasi (TTCI). Analisis menggunakan IBM SPSS Statistics 26 mencakup normalitas, N-gain, dan uji t independent. Hasil menunjukkan bahwa kedua kelompok mengalami peningkatan, tetapi kelompok Laboratorium Cassy mencapai N-gain yang lebih tinggi. Uji t menunjukkan perbedaan yang signifikan antar kelompok. Temuan ini menunjukkan bahwa praktikum berbasis Laboratorium Cassy efektif dalam meningkatkan pemahaman konseptual dan berfungsi sebagai media pembelajaran berbasis teknologi. yang inovatif. Penelitian lebih lanjut harus mengeksplorasi dampaknya pada keterampilan proses ilmiah, berpikir kritis, dan motivasi dengan sampel yang lebih luas.

INTRODUCTION

Education is a crucial foundation for improving the quality of human resources. This quality improvement can be achieved through strengthening understanding of theoretical concepts, developing personal skills, and fostering critical, analytical, and creative thinking skills (Raudhatussya'rifah, et al., 2025). In the 21st century, educational development has experienced significant acceleration. Education is now integrated with technological advances, giving rise to a variety of choices and innovations in learning media. Therefore, information technology-based learning media is increasingly important. Several studies have been conducted to develop learning media, including visual, audio, and interactive media (Cristi et al., 2026; Fajariani & Khairunnisak, 2026; Fernanda et al., 2026; Isnania et al., 2025; Kusuma

& Rozi, 2026). The use of digital learning media can strengthen student engagement, expand access to information, build digital literacy and critical thinking skills, and create more personalized and meaningful learning experiences for students (Faiza & Wardhani, 2024). Furthermore, the use of this media has been proven to significantly improve the quality of the learning process, thereby improving the overall quality of education (Febrina & Setiawan, 2024; Sawitri et al., 2024). Therefore, teachers and educational institutions are required to not only convey theory but also provide more interactive and meaningful practical and observational experiences for students.

Physics is a fundamental branch of natural science that studies, understands, and views various natural phenomena (Furqon, et al., 2025).. This science focuses on the interactions of the properties, behavior, and energy of matter, along with fundamental principles and theories at microscopic to cosmological scales (Khandagale & Chavan, 2017). However, students experience several difficulties in learning physics, particularly in understanding physical concepts and principles. Students struggle to understand physics concepts because of the excessive number of formulas, which are uninteresting, thus underachieving learning objectives (Daun et al., 2022). Teachers also often present material that is too theoretical and not applicable, making physics learning difficult (Astuti et al., 2022). Furthermore, teachers rarely provide contextual learning (Samudra et al., 2014). Improving understanding of physics principles and theories can be achieved through hands-on learning, practical work, and observation of natural phenomena.

Practical work is an essential part of physics learning because it strengthens students' understanding of concepts learned theoretically (Azmi et al., 2024). The integration of interactive learning media into physics labs has also been shown to improve student understanding. Augmented reality can bring abstract physics concepts to life, helping students better grasp the material (Purwanita et al., 2025). Similarly, video tutorials for physics labs have been shown to be highly suitable for use in online learning, facilitating a more effective learning process and enhancing student understanding (Hasan & Larumbia, 2021). In line with this, (Lia Felizarda Freitas, 2023) explains that practical activities support students in better mastering physics theories and concepts. Practical work also provides meaningful hands-on experience, stimulates learning interest, and concretely confirms the validity of theories in relation to what has been learned (Wahab et al., 2021). Therefore, lab work plays a crucial role in fostering deeper understanding and concrete experiences through observation, analysis, and direct demonstration of physics concepts.

Several previous studies have conducted lab work using various learning media. Salma et al. (2024) conducted a conventional lab work using an analog multimeter. Fatkhomi & Widiyanto (2025) used Padlet as a digital-based collaborative tool for a physics lab. Other studies have used the Virtual Lab application Phet as a physics learning tool in lab work (Andika et al., 2022; Arifin et al., 2011; Putra et al., 2020; Rahman & Sudarmono, 2022; Sharifov & Macisaac, 2022). Rahman & Sudarmono (2022) also conducted a lab work using the Android-based Every circuit application. However, most of these learning media have not been specifically optimized for calorimetry lab work, which requires high accuracy in measuring temperature changes.

Calorimetry is a practical activity in physics that utilizes a thermometer to measure temperature changes.

Calorimetry is also defined as a method used to measure the amount of energy transferred in the form of heat. This process is carried out using a tool called a calorimeter, a device used to determine the heat capacity and specific heat of an object (Aisyah et al., 2022). In calorimetry labs, temperature changes are typically measured using a laboratory thermometer. However, according to Kurniasari et al., 2022,, glass-walled alcohol thermometers have limitations, such as difficulty reading the scale and processing data directly. Furthermore, laboratory thermometers require recalibration to ensure measurement accuracy and tend to have a longer response time (Ramadhan et al., 2022).

To overcome these obstacles, innovation is needed in the form of using a digital thermometer integrated with Cassy Lab. Cassy Lab is a conventional practicum that is integrated mobile with a temperature sensor and a website-based application. Cassy Lab consists of a mobile Cassy and a Ni-Cr-Ni temperature sensor connected to the Cassy website application via a Wi-Fi network using a standard laboratory SSID and password. Once connected, the device is calibrated to ensure accuracy. This integration facilitates experimental data processing, presents visualization of measurement results, and supports a deeper understanding of physics concepts (Raudhatussya'rifah, et al., 2025). The use of Cassy Lab has also been carried out in training for laboratory assistants. The training results showed high effectiveness for students in improving conceptual understanding and practical skills. Therefore, this learning media innovation supports the improvement of knowledge and skills in accordance with the 21st-century learning paradigm.

However, research on the implementation of Cassy Lab as a learning medium in practicums is still limited. This condition results in technology's potential not being optimally utilized in improving the quality of physics learning. Therefore, this study aims to test the effectiveness of Cassy Lab on student learning outcomes, specifically in temperature and heat practicums. The urgency of this research lies in the need to improve practicum experiences that are more interactive, accurate, and digitally data-driven, thus supporting the creation of a more modern learning process.

METHOD

This study used a quantitative approach with a Quasi-Experimental design. This design employed a Non-Equivalent Control Group Design. This design involved two classes: an experimental group (O_1) and a control group (O_3). The experimental class received instruction using Cassy Lab, while the control class received conventional instruction. The experimental design can be seen in Figure 1.

Group	Pre-test	Treatment	Post-test
Experiment	O_1	X_1 →	O_2
Control	O_3	X_2 →	O_4

Figure 1. Research Design

Where O_1 is the pre-test score in the experimental class before treatment, O_2 is the post-test score after treatment, O_3 is the pre-test score in the control class before treatment, O_3 is the post-test score in the control class after treatment, X_1 is the instruction using the Cassy Lab experiment, and X_2 is the instruction using the conventional experiment.

In this study, the sample selection used a purposive sampling technique. This technique focuses data collection on individuals most relevant to the research needs, resulting in more comprehensive and in-depth information (Subhaktiyasa, 2024). This sample involved 20 second-semester Physics Education students, Faculty of Teacher Training and Education, University of Jambi. The study was conducted in September 2025. The sample used different classes, but with the same number of respondents per class. This selection was based on the students' basic physics skills and their active study of Basic Physics II.

Data collection techniques used pretests and posttest. The pretest was administered before the learning treatment was administered, while the posttest was administered after the learning treatment. The test instrument used was the Thermal and Transport Concept Inventory (TTCI) from Phys port in a multiple-choice format, utilizing concepts from physics, mathematics, and graphics. The test instrument consisted of 10 multiple-choice questions as shown in Table 1 (Febrianti et al., 2019). These questions were completed by students in each class for both the pretest and the posttest. The pretest was administered before the two classes were given the different treatments. Learning in the experimental class was treated by providing experiments using Cassy Lab, and the control class was treated by providing conventional experiments.

Tabel 1. The Question Grid of The Test Instrument

Indicator	Question Number
Phase change	1, 2
Rate of heat input to temperature change	3, 4
Equally divided temperature	5, 6, 7
Relationship between heat capacity and temperature change	8, 9, 10

The results of the pre-test and post-test responses were then collected and statistically tested. The data analysis stage involved two stages: prerequisite analysis and hypothesis testing. The prerequisite test used a normality test. The normality test is a prerequisite for conducting parametric tests (Sari et al., 2024). This test is used to determine whether the data is normally distributed. This test uses the Kolmogorov-Smirnov test. The decision criterion for this test is that if the significance value is greater than 0.05 (>0.05), the data are considered normally distributed, and if the significance value is less than 0.05 (<0.05), the data are not normally distributed. Hypothesis testing used the N-Gain Score and the t-test using IBM SPSS Statistics 26. The hypothesis testing analysis using the N-Gain Score aims to determine the effectiveness of the use of learning media. This analysis uses the following equation (Raudhatussya'rifah, et al., 2025; Hake, 1999) :

$$N - Gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score},$$

for the interpretation of the N-Gain Score value, the categorization results of the scoring can be seen in Table 2 (Hake, 1999; Herlawan et al., 2023).

Tabel 2. N- Gain Effectiveness Categories

Percentage (%)	Category
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Fairly Effective
> 76	Effective

The next test is the t-test. The t-test is a statistical method used to compare group, or sample means and measure the significance of differences between them. This study used two types of tests: the independent samples t-test and the paired samples t-test. This study used the independent samples t-test. This test examines whether there is a significant difference between the average scores of two unrelated groups. This data analysis was conducted by comparing the pretest and posttest results between the control and experimental classes to assess the effectiveness of the treatment (nuryadi et al., 2017).

RESULTS AND DISCUSSION

The research data were obtained from pre-test and post-test scores in a temperature and heat lab using calorimetry equipment. The scores were obtained from different treatments given to students in different classes. The experimental class used the Cassy Lab, and the control class used a conventional lab. The number of respondents in each class was the same, 30 students.

Table 3. Pre- test and Post-test Score in the Experiment Group

Parameters	Experiment Group	
	Pre- Test	***Post- Test***
Number of Students	30	30
Average	68, 27	89, 73
Maximum Score	60	83
Minimal Score	80	96

Based on the test results in the experimental class shown in table 3, the average pre-test score of 68.27 indicates that before the implementation of Cassy lab, students' understanding of the material on temperature and heat was still in the moderate category. The highest score in this treatment during the pre-test was 80, and the lowest score was 60. These results indicate that there is a variation in initial abilities among students in mastering the concept. After the implementation of the learning media, the post-test score experienced a significant increase with an average reaching 89.73. The highest score obtained was 96 and the lowest score was 83. The increase in maximum and minimum scores indicates that the increase occurred not only in students with high abilities, but also in students with lower initial abilities. Overall, these results indicate that the use of learning media in the experimental class has a positive and effective impact in improving learning outcomes.

Table 4. Pre- test and Post-test Score in the Control Group

Parameters	Experiment Group	
	Pre- Test	**Post- Test**
Number of Students	30	30
Average	55, 50	78, 10
Maximum Score	64	86
Minimal Score	48	70

In the control class, the pre-test and post-test scores can be seen in Table 4. The average pre-test score of 55.50 indicates that students' initial abilities are still relatively low, with a minimum score of 48 and a maximum score of 64. These results indicate that some students have not understood the concepts taught before the learning process. After the learning process took place, students' learning outcomes increased, where the average post-test score was 78.10 with a minimum score of 70 and a maximum score of 86. This increase indicates that there was a positive change in students' abilities after receiving learning treatment, even though learning was conventional.

Additionally, during the practicum, students in the experimental group used the Cassy Lab system to measure temperature changes in real time. The system allowed automatic data recording and graphical visualization, enabling students to directly observe the relationship between variables. In contrast, the control group relied on conventional tools, where measurements were taken manually and recorded periodically.

Therefore, these results generally indicate that conventional learning still has an impact on improving student learning outcomes, but the improvement is not as significant as in the experimental class that received the Cassy Lab-based practicum. These results will be further compared with the experimental class through statistical analysis to determine whether there is a significant difference in learning outcomes between the two classes.

Further analysis in this study is statistical analysis. This analysis uses normality tests, N-Gain tests, and t-tests, particularly the independent sample t-test. This testing uses SPSS Statistics 26 software. In the statistical testing, the experimental class is referred to as group 1, and the control class is referred to as group 2. The initial test in the statistical analysis is the normality test. The normality test aims to determine whether the data is normally distributed. The results of the normality test can be seen in table 5. The results of the shapiro-wilk statistical test show a sig value in the experimental class of 0.251, and the control class of 0.627. Based on the results of decision making, the results of the analysis of the two classes obtained that the test results were > 0.05. Therefore, the conclusion of the normality test in both classes shows that the data is normally distributed.

Table 5. Normality Test Results

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Learning Outcome	Statistic	df	Sig.	Statistic	df	Sig.
Group	1.00	.102	30	.200*	.956	30	.251
	2.00	.096	30	.200*	.973	30	.627

The next statistical analysis is a hypothesis test using the N-Gain Score and the t-test (Independent Sample T Test). The N-Gain Score test aims to determine the effectiveness of the use of learning media from both classes. The calculation results can be seen in Table 6. The average learning outcomes in the experimental class obtained a score of 67.37% and in the control class 51.83%. The categories of both results show quite effective results in the use of learning media both conventionally and using Cassy Lab.

The difference in learning outcomes between the two groups is not only reflected in the N-gain scores but also in the learning process. In the conventional practicum, students tended to focus on recording data manually, which limited their attention to conceptual interpretation. Meanwhile, the use of Cassy Lab enabled students to focus more on analyzing data patterns due to automated measurement.

Table 6. N- Gain Results

Group	N- Gain Score	Category
Experiment	67.37%	Fairly Effective
Control	51.83%.	Less Effective

Further analysis used t-test to determine the differences in learning outcomes in both classes. The results of the t-test calculations can be seen in Table 7. Based on the Independent Sample T Test, the results of the sign on Levene's Test for Equality of Variances show a value of 0.167 > 0.05. Therefore, the values of both classes interpret that the data variance is homogeneous. In addition, the results of the sign (2-tailed) show that the value is smaller than 0.05 (0.00 < 0.05) which can be concluded that there is a significant difference in learning outcomes between the implementation of practicum using Cassy Lab and conventional practicum.

Table 7. Independent Sampel T Test Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Class	Equal variances assumed	1.961	.167	8.719	58	.000	15.53333	1.78149	11.96729	19.09938
	Equal variances not assumed			8.719	53.624	.000	15.53333	1.78149	11.96108	19.10559

Based on the overall results, Cassy Lab offers several advantages, including real-time data acquisition, higher measurement accuracy, and immediate graphical representation. These features reduce human error and provide more precise experimental results compared to conventional methods. These advantages contribute to better conceptual understanding, as students can directly observe temperature changes and relate them to theoretical concepts. This explains why the experimental group achieved higher learning outcomes than the control group although both media are quite effective in supporting conceptual understanding.

The results of this study are consistent with several previous studies. Raudhatussya'rifah, et al. (2025) conducted training on the use of calorimetry equipment integrated with the Cassy app web. The results obtained showed an increase in conceptual understanding and a positive impact on laboratory assistants. Mayer & girwidz, (2019) also stated that the use of Cassy lab in schools is very good for student intuition. In addition, the integration of technology in learning also shows results relevant to this study. Langi et al., (2022) conducted a spring experiment using the Phyphox application as a learning medium. The results of this study showed that the use of the Phyphox application in the experiment was effective as a learning medium. Langngan et al. (2021) also conducted a viscosity experiment using virtual laboratory integration as a learning medium. This integration demonstrated effectiveness in learning. Therefore, the results of this study strengthen the finding that the use of cassy lab as a learning medium for physics practicums can significantly improve student learning outcomes compared to conventional methods. However, this study has limitations, including the relatively small sample size, limited generalizability of the results to other materials, and the reliance on the availability of digital laboratory equipment and stable connectivity. Given these limitations, further research on the integration of cassy lab with other digital learning platforms is needed to develop learning media.

CONCLUSION

This study demonstrates that using Cassy Lab as a learning medium for physics practicums effectively improves student learning outcomes compared to conventional learning. This improvement is evident in the significant difference between pre-test and post-test scores in the experimental and control classes. Therefore, integrating digital laboratory technology such as Cassy Lab could be an innovative alternative solution to improve students' conceptual understanding and practical skills in physics learning.

However, this study has several limitations, such as the limited scope of the material to a single practicum topic and the relatively small sample size. Therefore, it is recommended that further research be conducted with a broader scope of material, a larger number of participants, and the integration of Cassy lab with other digital learning platforms to optimize its application in various physics learning contexts.

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