Experiment Design and Laboratory Activities on Heat Transfer to Teaching Black Principle Topic in Science to Vocational Student for Supporting Sustainable Development Goals (SDGs)

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***Abstract*- This study aims to develop physics experimental learning tools on black principle material to improve vocational students' understanding through conventional learning supported by laboratory activities. In this research, the development of the black principle experimental learning tool was carried out using a design and development (DDR) approach. To evaluate learning, this research used a one-group pre-test and post-test design. The research subjects consisted of 21 vocational students at a vocational school in the city of Cimahi, West Java. Learning is carried out through conventional methods supported by laboratory activities which consist of four stages, namely: (i) pretest; (ii) delivering learning material; (iii) laboratory activities; and (iv) post-test. Laboratory activities are carried out by observing changes in the temperature of hot substances and cold substances when hot substances are passed through cold substances. To compare students' level of understanding before and after the learning period, pre-test and post-test data were evaluated using simple statistical calculations paired sample t-test. The results of the learning analysis show that laboratory activities can improve students' understanding even though the improvement is categorized as moderate. Laboratory activities in the classroom are a very effective way to strengthen understanding of scientific concepts and help students link theory with practice.**

***Keywords*-Black Principle, Heat Transfer, Laboratory Activity, Education, Vocational Student.**

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I. INTRODUCTION

Science learning does not only transfer information but must provide direct learning experiences for students that help students practically apply theoretical concepts introduced during learning (Ekamilasari & Pursitasari, 2021; Homdijah et al., 2022; Budiman & Armindony, 2022; Nwafor et al., 2024; Kranz et al., 2023; Samsudin & Raharjo, 2023; Sison et al., 2024). Laboratory experiments and activities are an active way of learning, through direct experience, and fun to gain a comprehensive understanding of science through scientific construction (Liana et al., 2022; Bugarso et al., 2021; Juhanaini et al., 2022; Rosina et al., 2021). The direct experience refers to the fact that students involve many senses (such as sight, touch, and smell) during learning. Indeed, it has an impact on achieving learning competencies and improving learning outcomes (Gya & Bjune, 2021; Cai et al., 2013; Olympiou & Zacharia, 2012). However, unfortunately, some laboratory activities only follow a very structured format that leads to known answers which are referred to as "cookbook" laboratories thus they do not provide lasting benefits and meaning for students and may even fail to lead students to analyze uncertainties, overcome errors, or challenging misconceptions (Davis et al., 2020; Shorlidge & Brownell, 2016; Narayanan et al., 2023). Based on this explanation, for science learning to be meaningful for students, learning needs to be facilitated with innovative learning media and not "cookbooks" that prioritize direct experience with an emphasis on investigative activities to foster competence in understanding nature scientifically.

Several learning media designs that have been carried out to achieve science learning competencies are explained in detail as follows. Based on literature, designed learning media related to thermal experiments for secondary students where the learning media they have successfully created has advantages such as users can quickly and easily set up and carry out experiments (i.e., all thermal phenomena such as introduction to thermal phenomena, calorimetry, heat distribution, and phase transformations) by directly manipulating objects on the computer screen and observing the results in various representations and temperature versus time graphs (Lefkos et al., 2011). The drawback is that hands-on experiences are used and carried out using a mouse and cursor only (just "clicking") thus students' psychomotor skills are not trained. Plant biology laboratory learning media at home that are cheap and simple are designed to involve students in the science process. Designed for students thus laboratory activities can be carried out outside the laboratory, for example off campus, like at home. The disadvantage of home plant biology laboratories is that home labs can potentially require more time than students spend doing scheduled labs because they require students to set up and monitor their own experimental systems and limited instructor supervision during the experimental process (Schnell et al., 2021). The development of IoT-based experimental media for the laws of thermodynamics has been designed to train students in scientific problem-solving. Learning media-IoT-based has the advantage of facilitating the limitations of the lack of experimental learning media. In addition, the advantage of IoT-based thermodynamic law experiment media is that the results of automatic time measurements and measurement data of high temperature (T1), low temperature (T2), electric voltage (V), and electric current (I) can be observed directly in a real way. However, the limitation of this learning media is that the use of IoT requires that objects exchanging information must be within wireless fidelity (wifi) range and the equipment required is complex and expensive (Liana et al., 2020). Then, learning media based on augmented reality (AR) Technology has also been designed to overcome the difficulties of science learning. This AR media has become popular in science learning because AR can provide complex information more understandably, teach subjects that it is impossible to observe directly, demonstrate dangerous phenomena, and objectify abstract concepts. However, the limitation is that the equipment required is complex and expensive (Sahin & Yilmaz, 2020).

The availability of appropriate teaching materials, tools, and equipment can facilitate the implementation of practical activities (Al Husaeni et al., 2024; Ana, 2020; Ruiz-Rojas et al., 2023; Ainun & Jefriyanto, 2023; Maryanti et al., 2022). However, in some schools, most of the main obstacles to carrying out practical activities are problems with the availability of tools and materials which cause learning activities to become monotonous. Monotonous learning activities reduce student interest and participation in the learning process, thereby affecting learning outcomes (Leif et al., 2023; Bunari et al., 2024; Sinay et al., 2023). One of the physics subjects that requires proof through practical work is determining the validity of Black's principle regarding the mixing of two substances, where the amount of heat released by the substance with a higher temperature is the same as the amount of heat received by the substance with a lower temperature (Padmaja and Sikindar Baba, 2020). The concept of mixing two substances that have different temperatures is interesting for students to research because this phenomenon can be found in everyday life, in various applications and industries.

Teaching basic black principles to vocational students has several reasons that may be relevant, especially when related to thermal principles or heat exchangers, and can become an integral part of the vocational curriculum. vocational students are expected to have capable in facing industry (Maryanti & Nandiyanto, 2021; Minghat et al., 2023; Anwar & Minghat, 2024; Hashim et al., 2024).

Several reasons why Black's basic principles are taught to vocational students include: (i) the concept of mixing two substances with a temperature difference has many applications in various industries and vocational professions, such as mechanical engineering, thermal engineering, or machining. Vocational students who understand these principles can apply them more effectively in the world of work; (ii) Vocational students who understand how to manage temperature in mixing processes can contribute to the optimization and efficiency of industrial processes; and (iii) vocational students need to understand the impact of temperature on materials and equipment. Thus, teaching these basic principles provides a strong foundation for vocational students to face the challenges of the industrial world involving temperature management and mixing processes. Learning outcomes related to physics material for the vocational level based on the independent curriculum in Indonesia are shown in Table 1.

TABLE I

PHYSICS LEARNING OUTCOMES AT THE SECONDARY SCHOOL LEVEL

Phase	Element	Learning Outcomes
F	Understanding Physics	Students can understand the concepts of heat and thermodynamics and their application in reviewing the efficiency of heat engines

To teach this black principle concept, several methods have been used. Detailed information for this concept and its application is explained elsewhere (Ragadhita & Nandiyanto, 2024). Learning material on black principles usually uses two glasses, one of which is filled with hot water and the other is filled with cold water, then the hot water and cold water are combined thus thermal equilibrium occurs. On the other hand, learning Black's principles also usually uses a tool called a calorimeter. A calorimeter is a tool used to determine parameters such as heat capacity, specific heat capacity, and latent heat capacity of an object or material where determining these parameters applies Black's principles. Thus, it cannot directly teach Black's principles. In addition, learning Black's basic principles with a calorimeter is felt to be less effective because the success of a calorimetry experiment depends on careful consideration of various factors, including the materials used, calibration methods, and the specific heat transfer mechanism being studied. Based on the previous explanation, to date, there has been no practicum regarding proof of Black's principle that is adequate, comprehensive, and practical, especially concerning vocational student learning outcomes regarding the application of heat energy principles and concepts.

Here, this research designs a practical practicum tool related to direct proof of the black principle which is designed with equipment that is simpler than a calorimeter and aims to increase vocational education students' knowledge and understanding regarding the concept of mixing two substances that have a temperature difference using learning conventional methods supported by laboratory activities. This study adds new information to support current issues in the sustainable development goals (SDGs) as reported elsewhere (Nurramadhani et al., 2024; Makinde et al., 2024; Gemil et al., 2024; Haq et al., 2024; Basnur et al., 2024).

II. METHOD

2.1. Designing of Experiment Learning Media Stages

The learning media design produced in this research is an experimental tool related to the black principle concept using a copper spiral pipe equipped with a battery-based pump to flow liquids with certain mass variations. The design of this learning tool consists of two stages, namely the mechanical design stage and the electronics design stage. In the mechanical design, the copper pipe is made into a spiral and designed above the storage (Storage 1) whose function is to hold cold liquid and submerge the spiral copper pipe. Then, the two ends of the spiral pipe are connected with a plastic pipe. The first end of the plastic pipe is connected to empty storage (Storage 2). Meanwhile, the plastic pipe at the other end is connected to a storage containing hot liquid (Storage 3). Each storage is equipped with a temperature detection device, namely a thermometer.

Next, electronic design is carried out on a battery-based pump (with certain variations in battery voltage) to transport hot liquid from storage 3 to a spiral copper pipe that is submerged in cold liquid (storage 1) and then exits to fill empty storage (storage 2). This pump, which is designed to use various variations in battery voltage, aims to transport hot liquids with various variations in liquid flow or liquid discharge which has implications for variations in the mass of the hot water liquid being transported. The hope is that when hot liquid is transported from storage 3 to a spiral copper pipe submerged in cold water (storage 1) and the liquid comes out to fill empty storage (storage 2), there will be a change in temperature in the form of a decrease in temperature to a relatively hotter temperature (in storage 3) after being transported to storage 2 and the temperature increases to a relatively cooler temperature (in storage 1) which can briefly be said to occur in thermal equilibrium. An illustration of the tool design is presented in Figure 1.

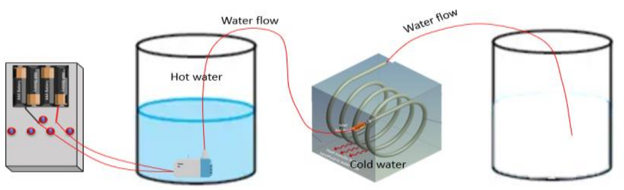


Fig. 1. Experiment Set

2.2. Procedure for Operating the Learning Media

The learning media design produced in this research is an experimental tool related to the black principle. To operate the experimental equipment, the first step that must be taken is to install three AA-sized batteries in the battery holder. Then, connect the switch in the form of a crocodile clip connected to a cable according to the desired voltage. Meanwhile, the voltages available in the experimental equipment are 1.5, 3.0, and 6.0 volts. After the crocodile clip switch is connected to the battery with a certain voltage, the hot liquid will flow from storage 3 to storage 1 and finally be collected in storage 2. The fluid that flows until it is collected fills storage 2 and is calculated using a stopwatch for 30 seconds for all voltage variations.

2.3. Testing and Implementation Learning Media Stage

After the experimental equipment has been successfully designed, the next stage is the experimental stage which is carried out by researchers to ensure that the experimental equipment works well. If there are deficiencies during the experiment, the experimental equipment will be repaired. After the experimental tools have undergone the testing and improvement process, the next stage is implementing the experimental tools in learning.

2.4. Research Subject

The subjects in this research were 21 vocational students majoring in software engineering at a vocational school in Cimahi, Indonesia. The subjects chosen were vocational students majoring in engineering because vocational students majoring in engineering receive natural and social science project subjects. This natural and social science project subject is a subject that integrates social science and natural science which studies objects in the form of concrete objects and social phenomena found in nature and is developed based on empirical experience, namely real experience felt by everyone and has a systematic step using logical thinking.

2.5. Research Design and Teaching Method

The research design used was a one-group pre-test post-test design. The instruments in this research are learning outcomes tests and assessment rubrics. The learning outcomes tests used are in the form of multiple choice and essays. The stages of data collection in this research are the preparation and implementation stages. The preparation stage includes: (i) reviewing the science and science subject curriculum at vocational schools; (ii) creating learning scenarios in class according to the material being taught; (iii) designing experimental tools used in learning; (iv) making student worksheets as practical guides; (v) create questions for the initial test (pretest) and final test (posttest). Here, the questions for the pretest and posttest consist of the same questions. Meanwhile, the implementation stage or learning stage is carried out through four stages as follows: (i) stage 1: pretest to measure students' level of knowledge regarding learning material; (ii) stage 2: delivery of learning material related to black principles using conventional methods where students listen to the material presented by the teacher; (iii) stage 3: delivery of learning material related to black principles through laboratory activities where students gain experience of being directly involved in learning which requires students to handle or carry out, observe and analyze a scientific process; and (iv) stage 4: posttest to determine the level of success in delivering the material, whether students absorbed the learning provided well or not.

2.6. Data Analysis

After data collection and collection, the research data is processed using descriptive statistical analysis and inferential statistical analysis. In detail, data analysis is explained next.

2.6.1. N-Gain Analysis

The N-Gain test aims to determine the significance of student learning outcomes between before and after learning after certain actions or treatments. The N-Gain test criteria are presented in Table 2.

TABLE II
N-GAIN CRITERIA

Limitation	Category
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Moderate
$g < 0.30$	Low

2.6.2. Validity Analysis

A validity test is a test carried out to show the extent to which a measuring instrument can measure something to be measured. To avoid invalidating the research results, each question item needs to be tested for validity. The validity test is carried out by calculating the product moment using the Kuder Richardson-20 (KR-20) formula. Interpretation of correlation coefficients for validity tests is categorized based on the following ranges: (i) 0.80-1.00 (very high); (ii) 0.60-0.80 (high); (iii) 0.40-0.60 (fair); (iv) 0.20-0.40 (low); and (v) 0.00-0.20 (very low). Based on the categories of correlation coefficient interpretation results, in this study, question items with very low validity categories are assumed to be invalid. The results of the validity test of the question items are shown in Table 3.

2.6.3. Reliability Analysis

Reliability is the stability of the scores obtained by the same person when retested with the same test in different situations or from one measurement to another. The reliability value can be determined by determining the reliability coefficient using the split-half method. The resulting reliability coefficients are then interpreted using the Guiforord criteria. The reliability test results are shown in Table 4.

2.6.4. Test the Difficulty Level of Question Items

The level of difficulty of a question item is the proportion of all students who answered correctly on that question item. It is very important to look at the level of difficulty of the questions to provide various diagnostic tools for student learning difficulties or to improve classroom-based assessment. The difficulty analysis was carried out based on the calculations of Robert L. Thorndike and Elizabeth Hagen's level. The results of the difficulty analysis are shown in Table 5.

TABLE III
RESULTS OF VALIDITY TEST OF QUESTIONS ITEMS

Limitation	Category
Number of questions	10
Number of students	21
Number of valid questions	6 (item number 1, 2, 4, 5, 6, and 10)
Number of invalid questions	4 (item number 3, 7, 8, and 9)

TABLE IV
RELIABILITY TEST QUESTIONS

Parameter	Note
r_{count}	0.90
Category	Very High

TABLE V
DIFFICULTY LEVEL OF QUESTIONS

Question number	Difficulty index value	Question category
1	0.380	Medium
2	0.476	Medium
3	0.648	Medium
4	0.904	Easy
5	0.785	Easy
6	0.619	Medium
7	0.476	Medium
8	0.928	Easy
9	0.904	Easy
10	0.619	Medium

2.6.5. Normality Test

The normality test is carried out first to find out whether the experimental class is normally distributed or not. The use of parametric and nonparametric statistics depends on the assumptions and type of data to be analyzed. Parametric statistics requires that many assumptions be met. The main assumption is that the data to be analyzed must be normally distributed. Meanwhile, non-parametric statistics do not require many assumptions to be met, for example, the data to be analyzed does not have to be normally distributed.

2.6.6. Significant Test through Paired Sample Test

Data analysis carried out in this research was to compare the average pre-test and post-test scores of the experimental class using the paired sample t-test statistical test. Through this paired sample t-test, the difference in the average post-test score of the experimental class will be known whether it is significantly different or not before and after learning. Detailed information regarding the use of SPSS is explained elsewhere (Fiandini et al., 2024).

III. RESULTS AND DISCUSSION

3.1. Students' Demographics

To obtain initial information, demographic data regarding grades in natural and social science subjects is also provided. This demographic data is presented to provide a better understanding of student composition and support learning planning. For example, demographic data is useful for helping teachers understand students' individual needs, thereby helping teachers monitor student progress by providing additional support to students who may need it to achieve academic success (Kolano et al., 2014). Data on students' natural and social science scores are categorized based on the following score ranges: (i) a score of 86-100 is categorized as very good achievement; (ii) a score of 75-85 is categorized as good achievement; (iii) a score of 65-74 is categorized as sufficient achievement; (iv) a score of 55-64 is categorized as low achievement; and (v) 0-54 is categorized as very low achievement. Based on demographic data, the average natural and social science score of students is 57.71, which shows that students' natural and social science achievement is in the very low category.

3.2. Experimental Apparatus

The experimental equipment related to the black principle sub-material used in this research is shown in Figure 1. This experiment regarding black principles aims to understand the concept of black principles and its application in everyday life. Black's principle states: "The heat released by a substance at a high temperature will be the same as the heat received by a substance at a low temperature". Mathematically, black's principle is expressed according to Equations (1) and (2).

$$Q_{release} = Q_{receive} \quad (1)$$
$$m_1 c_1 \Delta T_1 = m_2 c_2 \Delta T_2 \quad (2)$$

Where, *m*, *c*, and *T* are mass, specific heat capacity, and temperature, respectively.

The experiment was carried out by observing changes in liquid temperature as a function of mass where this mass variation was regulated by changing the voltage of the battery-based pump which functions to transport liquid stored in storage 3 to storage 2 via storage 1. To evaluate the black principle phenomenon, storage 1-3 is filled with liquid that has a certain mass, and one thermometer is placed in each of the three storage areas. Then, the temperature change in each storage is measured after 30 seconds of liquid being transported from storage 3 to storage 2 via storage 1.

The proof of black's principle is carried out with two different sets of liquid settings. In the first set, the liquids used are hot water and cold water. In the second set, the fluids used are hot water and radiator water. The results of students' experiments related to proving the good black principle using two different sets of liquids, namely hot water and cold water (liquid set 1) are shown in Table 6.

Based on the results of the black principle experiment in Table 7, the experimental results follow the black principle, where when two objects with different temperatures are combined or mixed, there will be a transfer of heat from the object with a higher temperature to the object with a lower temperature. This process will continue until thermal equilibrium is reached, where both objects reach the same temperature. This theory regarding Black's Principle is proven to be following the practical work carried out when hot water is passed through cold water, then the next process of mixing occurs. This mixing process causes the temperature of the hot water to fall and the temperature of the cold water to rise, or it is said that thermal equilibrium occurs.

TABLE VI
RESULTS OF EXPERIMENTAL TOOLS TO PROVE BLACK'S PRINCIPLE

Battery voltage (V)	**Volume of hot water (mL)**	**Initial temperature of hot water (°C)**	**Final temperature of hot water (°C)**	**Volume of cold water (mL)**	**Initial temperature of cold water (°C)**	**Final temperature of cold water (°C)**
6	450	50	48	500	25	26
6	450	50	46	1000	26	27
4.5	425	50	46	500	26	28
4.5	425	50	47	1000	26	29

TABLE VII
N-GAIN DATA FOR STUDENTS' CONCEPT UNDERSTANDING

No	Student Code	Pretest Score	Posttest Score	N-Gain	Category
1	A1	50	65	0.30	Moderate
2	A2	65	80	0.42	Moderate
3	A3	50	65	0.30	Moderate
4	A4	55	75	0.44	Moderate
5	A5	55	80	0.55	Moderate
6	A6	35	65	0.46	Moderate
7	A7	40	90	0.83	High
8	A8	40	65	0.41	Moderate
9	A9	40	80	0.66	Moderate
10	A10	45	85	0.72	High
11*	A11	55	50	0.00	Low
12	A12	40	75	0.58	Moderate
13	A13	35	90	0.84	High
14	A14	45	50	0.09	Low
15	A15	50	50	0.00	Low
16	A16	55	55	0.00	Low
17	A17	45	60	0.27	Low
18	A18	45	55	0.18	Low
19	A19	50	65	0.30	Moderate
20	A20	55	55	0.00	Low
21	A21	50	55	0.10	Low
Mean pre-experiment class		47.61	67.38	0.37	Moderate
Standard deviation		7.68	13.0	0.27	

3.3. Teaching Results

This teaching results from the subsection consist of several discussions, including descriptive analysis using N-Gain, normality test, and significance test using the paired sample t-test. During learning, students are given tests in the form of pretests (tests before learning to determine students' understanding before learning) and posttests (tests after learning). Then, the pretest and posttest score data were compared to analyze the extent to which students' ability to understand concepts had increased using the normalized gain formula (N-Gain). N-Gain data related to student understanding is presented in Table 7. Based on Table 7, the calculation results show that the average value of student learning outcomes related to basic black material before and after learning respectively is 47.61 and 67.38 from the ideal value of 100. Based on the difference in pretest and posttest scores, there is an increase in student learning outcomes of 19.77 or 19.77. %. This improvement in learning outcomes is also confirmed by the N-Gain value presented in Table 8. Based on Table 8, 8 people are in the very low category (38.09%), 10 people who are in the medium category (47.62%), and 3 people who are in the high category (14.28%). Based on the assessment results, there was an increase in students' interest in learning as evidenced by the increase in overall test scores on the posttest, where the increase in student learning outcomes was categorized as medium.

TABLE VIII
NORMALITY TEST RESULTS DATA BASED ON SHAPIRO-WILK

	Statistic	df	Sig.
Pretest Score	0.145	21	0.257
Posttest Score	0.192	21	0.60

To confirm the results of the descriptive analysis, the increase in students' understanding after the learning process was also analyzed using inferential statistical analysis to analyze the significance of the increase in students' understanding which was analyzed using the paired sample t-test. Before carrying out a significance test, a normality test is carried out first. As previously mentioned, the normality test aims to see whether student score data before and after teaching is normally distributed or not. Thus, the data can be used for analysis using the t-test. The data used for the normality test were pretest and posttest value data in one experimental class which was tested using the Shapiro-Wilk test. The basis for decision-making is if the Sig. is greater than $\alpha = 0.05$, H_0 is rejected, and if the Sig. is smaller than the value $\alpha = 0.05$ then H_0 is accepted. The data from the normality test results are shown in Table 8. The normality test results show that the pretest and posttest score data are normally distributed because the Sig. > 0.05.

After carrying out the normality test, the next test is the significance test to test the hypothesis of whether there is a significant difference in learning outcomes before and after learning. The hypothesis test used in this research is the paired sample t-test. The hypothesis in this paired sample t-test is that H_0 is rejected if the Sig. smaller than the value α

= 0.05, and H_0 is accepted if the Sig value. greater than the value α = 0.05. The results of the paired sample t-test are shown in Table 9. Based on the results of the paired sample t-test, the Sig. (2-tailed) obtained is 0.000. Sig value. (2-tailed) is smaller than 0.05, which indicates that H_0 is rejected, meaning that there is a significant difference in student learning outcomes using laboratory activities.

TABLE IX
RESULTS OF THE PAIRED SAMPLE T-TEST

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair: Pretest – Posttest Score	-19.762	16.769	3.659	-5.401	21	0.000

The results of the N-Gain analysis and inferential statistics show that the majority of students' scores before learning are below 60. The results of the N-Gain analysis are in line with demographic data on students' science and science scores which shows that students' science and science achievements are in the very low category. After learning was carried out using conventional methods supported by laboratory activities, students experienced increased understanding after learning through laboratory activities which were in the moderate category (based on the results of descriptive analysis via N-Gain). The results of the descriptive analysis were also confirmed by the paired sample t-test which showed that students' understanding after learning experienced a significant increase. Even though based on the N-Gain analysis, this improvement is categorized as "moderate" and may seem insignificant for a very high increase, it is important, especially if the majority of students experience improvement. Based on the results of this descriptive and inferential analysis, there is an increase in students' understanding due to practical or experimental activities which have an important role in supporting the success of the learning process because with experiments students can find out in detail the problems faced which require students to practice applying theories, concepts, procedures, and skills.in real or artificial situations in a programmed or structured manner under the direct supervision or guidance of the teacher (Hernandez-de-Menendez et al., 2020; Elme et al., 2022; Mistry & Gorman, 2020; Farley et al., 2020; Seifan et al., 2020; Anitha et al., 2018; Nandiyanto et al., 2020). Through practical or experimental activities, students also carry out experiments by experiencing and proving for themselves what they have learned. Other research also shows that through these laboratory activities, students are trained to work scientifically in understanding phenomena and events through the process of observation, experimentation, as well as empirical and analytical activities (Gericke et al., 2023; Olympio & Zacharia, 2012; Özer & Sarıbaş, 2023; Hurtado-Bermúdez & Romero-Abrio, 2023; Kennepohl, 2021; Smith et al., 2020). Apart from that, through this activity it will also be easier for students to form their understanding, thereby encouraging students to be more active in learning and can improve student learning outcomes (Putri et al., 2020).

3.4. Qualitative Analysis

Qualitative analysis in this research has an important purpose in the context of evaluation and learning such as providing valuable information for teachers in spotting common error trends or difficulties that may require adjustments in teaching methods. To analyze the questions, Bloom's taxonomy is used first to categorize the questions. Table 10 shows a comparison of the percentage scores for each question between the pretest and posttest stages.

Based on Table 8, after the learning process was carried out, the overall post-test score increased. The pretest questions most often answered correctly by students (the percentage who answered correctly was at least 50%) were question items number 6, 8, and 9. Meanwhile, after learning, the questions most often answered correctly by students were question items number 3, 4, 5, 6, 8, 9, 10. Although overall there was an increase in the percentage of correct answers in each question item after the learning process, students still answered questions 1, 2, and 7 incorrectly (as shown by the asterisk symbol in Table 9). This is because questions 1, 2, and 7 are types of questions that require logical thinking. Several factors can explain why some students may have difficulty answering questions that require logical thinking, including:

(i) Students lack training and practice related to solving case problems as a result of which students are not familiar with the types of questions or problems that require logical thinking, thus students may have difficulty dealing with them (Yayuk & As'ari, 2020).

(ii) Students have deficiencies in skill development because logical thinking is often related to critical skills such as analysis, evaluation, and synthesis of information. Students who have not developed these skills may face difficulties in formulating logical answers (Khairy et al., 2021; Evans & Over, 2013; Jawad et al., 2021).

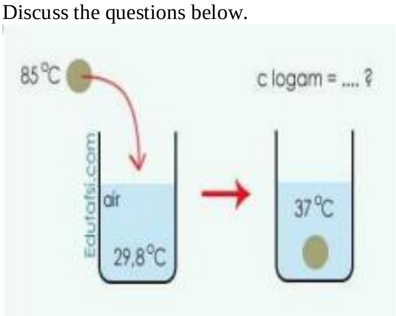
(iii) Students do not understand the concept. Thus, students may have difficulty answering logic questions if they do not understand the underlying concept or information (Cheah, 2020).

(iv) Students have deficiencies in abstract thinking because logical questions require abstract thinking and the ability to see relationships or patterns that may not be immediately visible (Oljayevna & Shavkatovna, 2020).

(v) Students are not motivated to complete logic tasks. If students do not feel motivated or see the relevance of a logical question, they may be less motivated to find a solution (Astuti et al., 2021).

(vi) Students do not understand the instructions contained in logic questions, resulting in incorrect answers (Eyisi, 2016).

TABLE X
COMPARISON OF PRETEST AND POST-TEST SCORES FOR EACH QUESTION ITEM

No	Question	Bloom Taxonomy	Pre-test Score (%)	Post-test Score (%)
1	Mother puts 100 g of ice at 0ºC and 100 g of water at 0ºC into a room at 27ºC. After waiting long enough for the system to balance, the substance that has a higher temperature is…. a. No higher temperature b. Water c. Ice d. Can not be determined	C4	33.33	38.09*
2	The reason for question number 1 is…. a. Water gets heat from its surroundings b. Water is hotter than ice cubes c. Ice cubes and water have the same temperature d. The ice will transfer the cold to the water	C4	42.86	47.61*
3	Ferdi is renovating his damaged garage. For the time being, Ferdi's car was parked in the yard without a shade roof. He put a bottle of drink in the car cabin. After being under the hot sun for 3 hours, the temperature inside the car reached 40ºC. The possibility that can happen to a bottle of drink after 3 hours of being left in the car is... a. The water in the bottle is at the same temperature b. The water in the bottle may boil after some time c. The water in the bottle has a higher temperature d. The water in the bottle has a lower temperature	C4	45.24	64.28
	Questions number 4-8			
4	Discuss the questions below.  What substance releases heat? Why?	C4	47.62	90.48
5	Based on the figure in question number 4, what substance receives heat? Why?	C4	30.95	78.57
6	Based on the case in question number 4, after the two substances are mixed, what are the temperature conditions of the two substances?	C4	61.90	73.81
7	Based on question number 7, draw a graph of temperature versus heat!	C3	0	47.61*
8	Based on questions number 4 and 7, write a formula to find temperature changes in substances that release and receive heat! And write down the meaning of the formula!	C2	69.05	92.86
9	The following statement which is following Black's principles is…. a. Hot coffee added with ice cubes will have a constant temperature b. If warm milk is left to cool, it will become cold c. The heat added to hot milk will become warm milk d. If hot milk is added with ice cubes it will become cold milk	C4	85.71	90.48
10	Vika makes iced tea by mixing hot tea with ice cubes. Mother made warm water for her sister to bathe by mixing hot water with ordinary well water. Bella mixes hot milk with cold water to get warm milk. The following statements that correspond to these three events are…	C4	47.62	61.90

No	Question	Bloom Taxonomy	Pre-test Score (%)	Post-test Score (%)
a.	Mixing objects with high temperatures and low temperatures will produce a mixture with a temperature between the two, Black Principle			
b.	Mixed temperature is a shift in temperature from high to low. Black's Principle			
c.	Heat transfer occurs from a high-temperature object to a low-temperature object, a melting event			
d.	These three are examples of the concept of Black's Principle, which states that if two objects of different temperatures are mixed, then the temperature of the mixture is smaller than the smallest temperature of the material.			

CONCLUSION

Strategies to increase students' understanding of physics learning, especially regarding basic black material, have been successfully demonstrated. In this research, the learning strategy used to increase students' understanding is by combining conventional teaching methods and laboratory activities. During laboratory activities, the learning media used is a simple heat transfer experiment tool. The results of the analysis show that the strategies used in learning increase students' understanding, even though this increase is categorized as "moderate" and may not seem significant to experience a very high increase, it has an important meaning because the majority of students experience improvement. This increase in understanding is possible because of the laboratory activities that are integrated into conventional learning which can build students' active role during the learning process thereby motivating and requiring students to practice applying theories, concepts, procedures, and skills during learning. The limitation of this research is that the experiment only involved one group experiment. Thus, it does not have a strong basis for making comparisons. However, even though it only involves one group experiment, this study can be used to explore the problems being researched or develop certain ideas, methods, or tools. Therefore, we will work on improving the limitations of this research in the future.

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