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Call for Papers
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Journal of Research in Educational Sciences

The Journal is designed to promote scholars' thought in the field of education with the clear mission to provide an interdisciplinary forum for discussion and debate about education's most vital issues. We intend to publish papers that contribute to the expanding boundaries of knowledge in education and focus on research, theory, current issues and applied practice in this area.

The Editor in Chief would like to invite submissions for the **Volume XVII, Issue 1(21), Summer 2026** of the **Journal of Research in Educational Sciences** (JRES).

The primary aim of the Journal has been and remains the provision of a forum for the dissemination of a variety of international issues, empirical research and other matters of interest to researchers and practitioners in a diversity of subject areas linked to the broad theme of educational sciences.

The aims and scope of the Journal includes, but is not limited to; the following major topics as they relate to the Educational Sciences:

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- Engagement and Community;
- Leadership in Education;
- School Improvement;
- Human Resources in Education;
- Education and Information Science;
- Global strategies in Higher Education;
- Learner's Needs in the 21st Century;
- The Role of Education in The Globalization World;
- Technology-Based Learning.

All papers will first be considered by the Editors for general relevance, originality and significance. If accepted for review, papers will then be subject to double blind peer review.

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Development of Students' Workbook with STEAM-Real World Problem to Improve Middle School Students' Problem-Solving Skills on Temperature and Heat Material

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Abstract: Problem-solving skills are essential for students to face the challenges of the 21st century. However, based on observations and PISA 2022 data, junior high school students in Indonesia still have low problem-solving skills. The learning media used in the learning process is still conventional, still does not support problem-solving skills. This study aims to develop learning media in the form of students' workbooks with STEAM-Real World Problem content to improve students' problem-solving skills in temperature and heat material. The development followed the 4D model (Define, Design, Develop, Disseminate). The product was validated by 2 media and material experts, and readability was tested by 2 science teachers and 10 students. A total of 8 pretest and posttest questions covering problem-solving indicators were tested for validity and reliability, with valid results and a Cronbach's Alpha value of 0.665 (reliable). The empirical test involved 26 grade VII students. The effectiveness test used a quasi-experimental design with a non-equivalent control group model in two classes (28 students each). Results showed significant improvement, with an N-Gain of 61.81%. The "implementing the plan" indicator showed the highest increase, from an average score 8.81 (pretest) to a score of 68.19 (posttest). This improvement was supported by workbook activities such as designing a simple cooler, creating a poster, and calculating heat. These activities can provide space for students through experiments, visualization, creativity, and mathematical calculations. Thus, the students' workbook developed has valid, reliable, and effective criteria in improving students' problem-solving skills.

Keyword: students' workbook; STEAM; problem-solving skills; temperature and heat.

JEL Classification: I21; I23; C02.

Introduction

Education will always continue to evolve with the times. Education plays a very important role for every nation and country in creating a generation that is able to adapt to technological advances. Developments in the 21st century require students to be prepared to survive in a rapidly changing world and to create students who are able to compete in the world of education, both in academic and non-academic fields (Kain *et al.* 2024). These skills, often referred to as 21st-century skills, are the development of 4C competencies: communication, creativity, critical thinking and problem-solving, and collaboration (Herlinawati *et al.* 2024). Problem-solving skills are very important for students in facing developments in the 21st century, so that students can effectively solve problems they encounter in their daily lives (Bessas *et al.* 2024).

Problem-solving skills are high-level thinking skills that require students to analyze problems, evaluate actions, and find appropriate solutions. Problem-solving skills can also be defined as the process of finding, organizing, and presenting information to solve problems that arise in students' daily lives (Boetje *et al.* 2024). In addition, problem-solving skills are very important in science learning to build a deeper understanding in students to train them to independently discover various concepts (Schäfer *et al.* 2024).

Indonesian students' problem-solving skills are still relatively low. Based on the results of the Program for International Student Assessment (PISA), where the average score of Indonesian students in the creative problem-solving domain is significantly below the OECD average, with most students only able to solve simple problems (OECD, 2014). This low achievement is influenced by the lack of emphasis on problem-solving learning in the Indonesian curriculum when compared to countries such as Singapore (Safrudiannur & Rott, 2019). This finding is in line with the results of PISA 2022 which showed that 59% of Indonesian students were below the minimum proficiency level in mathematics, reading, and science which are closely related to critical thinking skills and contextual problem-solving (OECD, 2023). Problem-solving skills are closely related to learning activities. If students are unable to solve problems in physics, their learning activities will be disrupted and their involvement in the learning process will tend to decline. The application of problem-solving skills in physics learning can show that they can gain meaningful learning experiences and that physics material is closely related to students' daily lives (Muñoz Alvarez *et al.* 2025).

Physics education has great potential to improve students' problem-solving skills. Temperature and heat are closely related to real-life contexts, making them important basic concepts in the physics learning process. However, many students still find it difficult to understand energy changes and heat transfer, which confirms that temperature and heat are basic concepts that students often struggle with (Brundage *et al.* 2024). Although students still find physics learning complicated, mastering physics concepts is important in finding solutions and solving problems they encounter in their daily lives. Physics learning requires structured problem-solving stages. The problem-solving stages that can be used in physics learning are the problem-solving model proposed by George Polya.

According to Pólya (1973), the stages of Problem-solving include understanding the problem, making a plan, implementing the plan, and re-checking the results obtained. There are previous studies that have implemented Polya's problem-solving stages in learning, such as in the study of Chacón-Castro *et al.* (2023) which shows that the application of Polya's problem-solving steps can strengthen students' problem-solving skills in the context of differential equations and can also be used as a reference to improve students' ability to connect concepts with real-world problem-solving in physics learning in the classroom, especially in the material on temperature and heat. However, this study has not yet integrated a conceptual or real-world approach and is not based on STEAM-real world problems.

The approach that can be used to improve problem-solving skills is the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach. The STEM approach has developed into STEAM by adding elements of art to strengthen aspects of creativity and contextual understanding in learning. According to Yulianti, *et al.* (2024) the integration of art in STEAM not only expands the problem-solving approach but also supports the achievement of Education for Sustainable Development (ESD) goals. This approach encourages students to think critically, creatively, and collaboratively in facing real-world challenges. The STEAM approach aims to equip students with the skills needed in the 21st century and has been the focus of research for the past decade. The role of the STEAM approach in the 21st century is very important in equipping students, so its implementation needs to use a learning approach that can actively involve students (Yulianti, *et al.* 2024).

In its implementation, the STEAM approach can be combined with real-world problem-based learning strategies. According to Connor *et al.* (2015) this approach focuses on student problems that are relevant to everyday life. The combination of the STEAM approach with Real World Problem-based learning can build student knowledge in developing problem-solving skills and creating a good learning atmosphere. According to Yakman (2008) the STEAM approach is an integrative model that combines the fields of science, technology, engineering, art, and mathematics in one interrelated learning framework. The STEAM approach aims to build interdisciplinary connectivity as a whole, not only focusing on mastering content, but also improving creative and critical thinking skills in improving understanding of real-world problems. The addition of arts elements includes not only visual arts, but also language, humanities, and social sciences. The addition of arts reflects the importance of the creative aspect in understanding and applying science and technology.

The implementation of STEAM-real world problems in the learning process can be optimized by using learning media that is appropriate for students. One effective medium for learning is the student workbook, as it serves as a guide for structured activities that encourage students to actively build knowledge independently through systematic activities. Student workbooks can be an important tool for students in the learning process to facilitate exploration and reflection in learning activities (Falbe *et al.* 2023). Student workbooks with STEAM-real world problem content can be found in simple concepts that exist in everyday life. These concepts are integrated into the fields of science, technology, engineering, arts, and mathematics that are relevant to technological advances and have been proven to increase students' creativity and skills in facing developments in natural sciences and technology (Filipe *et al.* 2024). Therefore, students' workbook learning media are suitable for use as an effective means of improving problem-solving for junior high school students to deepen their understanding of concepts in the topics of temperature and heat.

Based on data analysis from interviews and observations conducted with teachers and students in grades VII and VIII at a junior high school in Malang City, it was found that the learning resources used still have limitations in helping students understand the concept of temperature and heat. Learning resources generally used by teachers include student worksheets, presentations in the form of Power Point (PPT), and various other methods designed to help students understand the material. However, they still find it difficult to understand basic concepts, such as how to interpret observation results, understand the relationship between variables, and process information into a deeper understanding.

Observations with science teachers at a junior high school in Malang showed that teachers did not have media that was exactly the same as the students' workbooks. In addition, the learning media currently used has not undergone much development, especially in the context of implementing the Merdeka Curriculum Merdeka Curriculum. Generally, teachers still rely on teaching materials in the form of Student Worksheets that only contain a small amount of information and explanations related to the material on temperature and heat. This causes students to have difficulty understanding the concepts contained in the material. In addition, it has not been able to improve problem-solving skills and is not integrated with STEAM aspects. Based on the results of the needs analysis that has been carried out, teachers need a students' workbook learning medium to facilitate the improvement of students' problem-solving skills in temperature and heat material.

Based on a study by Co (2025), the use of workbooks as supplementary teaching materials to improve science learning using traditional teaching methods has been proven to significantly improve student learning outcomes in science. Thus, workbooks can improve science learning outcomes. However, this study is still limited to the use of conventional workbooks and has not yet been integrated with the STEAM approach, which links learning to real-world problems. In addition, this study is not yet based on problem-solving skills. Similar research was also conducted by Putri *et al.* (2025) stating that learning media by developing a thermodynamics physics e-book that integrates local coal production policies with the STEAM-PjBL approach has been proven to be valid, practical, and effective in improving students' computational thinking skills with an n-gain value of 0.66. However, this study has not developed a problem-solving-based students' workbook and has not linked it to real-world problems.

Based on the results of the two studies above, the author now wants to develop a product that has integrated STEAM-real world problem content and has problem-solving indicators, namely the students' workbook learning media. Based on the explanation of the problem that has been presented, this study focuses on "Development of Students' Workbooks with STEAM-Real World Problem Content to Improve Problem-solving Skills of Junior High School Students on Temperature and Heat Materials", which aims to 1) identify the need for students' workbook learning media with STEAM-real world problem content for junior high school students to improve problem-solving skills on the topic of temperature and heat, 2) develop students' workbooks with STEAM-real world problem content for junior high school students on the topic of temperature and heat to improve valid and feasible problem-solving skills, and 3) test the effectiveness of students' workbooks with STEAM-real world problem content in improving problem-solving skills of junior high school students.

1. Literature Review

1.1 Students' Workbook

Currently, the world of education has entered the era of revolution 4.0, where in this era it is required to be able to create interactive and personalized student learning experiences that encourage critical thinking, problem-solving, and creativity. Therefore, in facing the challenges of the industrial era 4.0, the transformation of human resources in the education sector must continue to develop. Educators are tasked with identifying and developing the skills needed in the face of change. The 21st century skills needed to meet the needs of education, because it can realize a learning model that suits current needs (Saleem *et al.* 2024). One form of learning innovation that supports the development of student creativity and learning independence is the students' workbook. Students' workbook is a combination of books and student worksheet specifically designed as a learning resource for students to learn the material. Students' workbooks developed must meet the criteria of content that is in accordance with the curriculum, contextual, contains STEAM aspects, and also needs to contain assessments that reflect indicators of problem-solving skills. Students' workbooks can provide opportunities for students to practice independently, test their understanding, and support students to improve their skills in understanding the concepts they have learned. The students' workbook also contains objectives, materials, and several learning activities related to temperature and heat material (Castro-Velásquez *et al.* 2024).

According to Muliyati *et al.* (2023) the development of STEM project-based worksheets for physics learning which aims to evaluate the suitability of STEM-PjBL worksheets as learning media that can assist teachers in teaching renewable energy topics. This worksheet has several components in it that can help students understand renewable energy material effectively through project-based activities. However, the development of the student worksheet is still limited to the STEM approach that has not included Arts (A) elements, the connection to real world problems is still limited, and does not focus on problem-solving indicators. Similar research was also conducted by Annuš *et al.* (2024) to develop the Learn with M.E digital platform which includes a digital students' workbook feature aimed at supporting mathematics learning at the K-12 level. The results of the study show that digital workbook students are able to provide facilities in learning and help students learn according to their abilities. However, this research still does not integrate the STEAM-real world problem approach and there are no problem-solving skills.

1.2. Problem-Solving Skills

Teachers really need learning methods during the teaching process in order to achieve the expected targets. The methods provided must be able to make students achieve optimal learning achievements and as expected. Problem-solving skills are very important for students to overcome challenges, make the right decisions, and achieve the desired results. Problem-solving skills can be used to analyze a problem and design a solution strategy to find relevant solutions, and consider alternative results that will be obtained as needed (Tursynkulova *et al.* 2023). Problem-solving skills are used to challenge students in question their prior knowledge, increase curiosity, and encourage the search for solution ideas during the learning process (Stuppan *et al.* 2025).

According to Busyairi *et al.* (2023) the development of physics learning aids designed with the STEM-creative problem-solving model on dynamic electricity material is proven to have high validity and it can be concluded that the physics learning aids that have been developed are suitable for use in the trial stage and disseminated. This physics learning aid is used to improve problem-solving creativity in students.

1.3. STEAM

According to Portillo-Blanco *et al.* (2024) STEM education has been around since the early 1990s, STEM can create meaningful learning experiences to equip students with 21st century skills. At learning using the STEM approach requires learning related to real-world problems. According to Filipe *et al.* (2024) the change from STEM to STEAM with the addition of the element “A” (Arts) has a huge impact on the world of education. The addition of arts elements to science, technology, engineering and math learning aims to increase creativity and innovation through an arts approach, and can encourage students to experiment and create new solutions in solving problems. The STEAM approach enhances motivation, collaboration and can foster 21st century skills, making learning more meaningful and relevant to real-world challenges.

According to Trowsdale *et al.* (2024) the development of STEAM-based learning through “The Imagineerium” and “Teach-Make” projects using the Trowsdale Art-Making for Education (TAME) curriculum model focuses on real-world and transdisciplinary practices that integrate Science, Technology, Engineering, Arts, and Mathematics into project-based learning. The use of STEAM methods in the Trowsdale Art-Making for Education (TAME) approach is proven to be used in education that focuses on real-world transdisciplinary practices, so as to increase creativity and problem-solving in elementary school students.

1.4. Temperature and Heat

Physics is a branch of science that studies natural phenomena related to matter, energy, space, time, and the various forces that affect them. One important topic in physics is temperature and heat, where the concepts covered include the shape of objects due to heat, the black body principle, and heat transfer (Melita *et al.* 2023). Temperature and heat are closely related to everyday life. At the junior high school level, the material taught related to temperature and heat includes basic concepts of temperature and heat, temperature measurement, heat transfer, and other basic thermodynamic concepts. However, the material on temperature and heat is known to be difficult for students to understand. Studies show that many students still have difficulty distinguishing between the concepts of temperature and heat, as well as connecting temperature with physical measurements (Xing *et al.* 2023).

According to Awudi *et al.* (2023), the application of the demonstration method in teaching the concept of heat has been proven to improve students' conceptual understanding, as it encourages students to be more active and critical and enables them to relate the concept to real-world problems. This study also concluded that learning about heat is proven to be effective using the demonstration method. However, this research has not yet been integrated with STEAM content and does not yet include in-depth aspects of problem-solving skills.

Broadly speaking, students' problem-solving skills still need to be improved. The use of learning media can support students in overcoming difficulties encountered during learning. Based on some of the above studies that have discussed related to the making of student worksheet that use several methods and learning models of Discovery Learning and PjBL, Problem-solving, and temperature and heat material using teaching modules based on Problem Based Learning can optimize student activeness in the learning process and help them in trying to find problem-solving and create memorable learning experiences. However, the student worksheet used only consists of activity sheets and evaluation questions. The use of Hypercontent-based Discovery Learning learning model on temperature and heat material is not conducive. This is because many students' smartphones still do not have QR-code applications and earphones to listen to learning videos properly. Some researchers only use research subjects in one class.

Based on previous research, the development of teaching materials is still conventional, has not been integrated with the STEAM approach, is not associated with the context of real world problems, and does not contain problem-solving indicators. Seeing these limitations, the author sees the need to develop products in which not only contain problem-solving indicators, but also integrate the STEAM approach and real world problems. The author develops a STEAM-real world problem student's workbook which contains temperature and heat learning materials presented in a logical order, contains exercises, questions, activities, tasks designed to help students deepen their understanding of temperature and heat material, and is integrated with the STEAM approach by using 2 classes as subjects, namely classes that use student's workbook in learning (as an experimental class) and classes whose learning does not use student's workbook (as a control class).

2. Method

This research is a development study using a Research and Development (RnD) model focused on creating learning products in the form of materials, media, tools, and learning strategies that are useful for learning rather than for testing theories. The main focus of this research is to produce innovative learning media, then test the effectiveness of the products to determine whether they are suitable for use in the learning process (Pratama, 2025). This study focuses on the development of Students' Workbook with STEAM-Real World Problem content on temperature and heat material for grade 7 junior high school. The sampling technique in this study was purposive sampling. The research and development design model used in this study is 4-D development developed by (Thiagarajan *et al.* 1974). Figure 1 depicts the research flow, which was modified based on the method introduced by Thiagarajan, it illustrates the structured steps undertaken to achieve the research objectives. This 4D model consists of 4 stages, namely define, design, develop, and disseminate or can also be abbreviated as 4D. The stages in 4D development are arranged simply, can be easily understood, simple, and its implementation takes place systematically. In addition, this development model is generally applied in the development of books or teaching materials. Furthermore, to test the effectiveness of the product, the design used in this study was a quasi-experimental design with a non-equivalent (pretest and posttest) control-group model with two groups which appears in table 1 (Creswell, 2014), namely the class that used students' workbooks (experimental class) and the control class that did not use students' workbooks.

Figure 1. Product Development Framework Using 4D Stage

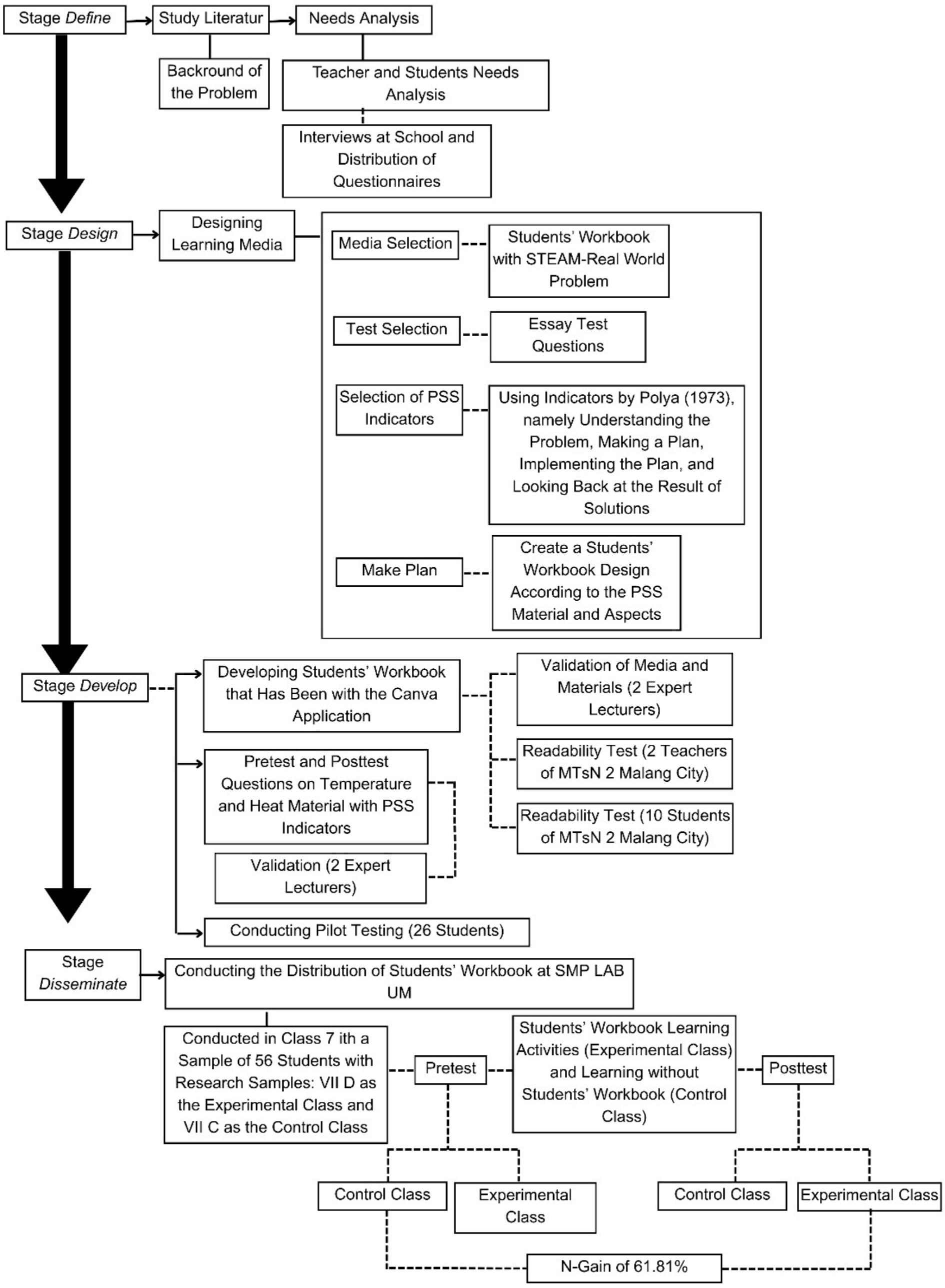


Table 1. Research Design

Group	Pretest	Treatment	Posttest	information
Experimental	O	X1	O	Was given treatment using the students' workbook
Control	O	X2	O	Conventional learning treatment uses teaching modules

Source: (Creswell, 2014)

Description:
O : Measurement (both pretest and posttest)
X_1 : Treatment (learning using students' workbook)
X_2 : Treatment (conventional learning using teaching modules)

The first stage is the defined stage which can help in determining and providing explanations related to needs and collecting information about user needs that will be included in the product. This study was conducted in three different junior high schools in Indonesia. Junior High School A was used to analyze the initial needs for learning media, Junior High School B was used to test the validity of the media developed prior to implementation, while Junior High School C was the location for the implementation of media that had undergone the development and validity testing stages previously. The needs analysis was conducted at Junior High School A which was conducted by interviewing science teachers, grade VII students (who had not received temperature and heat learning), and providing instruments in the form of questionnaires to grade VIII students (who had received temperature and heat learning) to identify the problem-solving skills gap and the need for students' workbook media with STEAM-Real World Problem content on temperature and heat material.

The second stage is the design stage, which includes designing learning media for students' workbooks with STEAM-Real World Problem content such as determining a theme that is in accordance with the temperature and heat material so that it looks attractive to junior high school students, finding information about the material that is in accordance with the curriculum and learning outcomes of junior high school, choosing good fonts and colors so that they are easy to read, determining a cover design that reflects the theme of the material, and determining the code for the STEAM category. Then, create several activities that are arranged to support students' understanding in improving problem-solving skills.

The third stage is the development stage, which includes the creation of a product in the form of a learning media for students' workbooks with STEAM-Real World Problem content. At this stage, product development and design, such as font selection, color, placement of graphic elements, STEAM icons, and creation of book covers using the Canva application. Students' workbooks with STEAM-Real World Problem content are designed based on needs analysis, curriculum suitability, and characteristics of junior high school students. In the students' workbook, there is material on temperature and heat and several activities with STEAM-Real World Problem content to improve problem-solving skills. At the development stage, there are also supporting instruments in the form of pretest-posttest questions containing problem-solving indicators according to Pólya (1973). Table 2 shows that the questions developed consist of 8 problem-solving questions containing different indicators for each question.

Table 2. Aspects of Problem-solving Indicators in Instruments essay test and Media

Indicators Problem-Solving	No Questions on Pretest and Posttest
Understanding the Problem	1, 2, 4, 5, 6, 7, 8
Makin a Plan	1, 2, 4, 5, 6, 7, 8
Executing the Plan	1, 2, 3, 4, 5, 6, 7, 8
Looking Back at Results or Solutions	3, 4, 6

After the product is developed, the next step is the validation process by material experts and media experts, followed by a readability test by teachers, a readability test by students who are asked to assess the feasibility, content and appearance of the product. The product consisting of students' workbook learning media and pretest posttest questions is validated by two science lecturers who are experts in physics and learning media. Validation is carried out to obtain input, criticism, and suggestions from experts so that the product can be improved before being tested, so that it can increase the effectiveness, readability, and suitability of the product to the needs of students and the curriculum. At this stage, the validation results obtained quantitative data, namely the assessment of the two validators using a validation sheet with a Likert (1932) assessment scale criteria 1-4, as well as from the results of the validation of the concept truth using the Guttman scale (1944), where each correct answer is given a score of 1, while the wrong answer is given a score of 0. The validation results from the two validators are used as a reference for revision and to perfect the product before being tested and the validation results are analyzed to calculate the percentage of feasibility.

After that, the product can be declared fit for use. Furthermore, a readability test was conducted on the students' workbook media by two science teachers and 10 students, which aimed to determine whether the use of the students' workbook could be understood and used properly. In addition, there was also a trial of the questions (empirical test) on the pretest and posttest questions to ensure that the instrument had met the validity and reliability requirements. Research instruments can only be considered high quality if they have high validity and reliability (Sharma *et al.* 2024). The validity test was conducted to ensure that the instrument actually measures the intended aspects. Meanwhile, reliability was tested to determine the level of stability of the measurement results of the instrument. According to Desnita (2022), Validity indicates the extent to which an instrument is able to accurately measure what it is supposed to measure, while reliability describes the stability of measurement results when used under the same conditions. The empirical test was conducted at junior high school B to 26 grade VII students. The questions given were 8 questions that tested problem-solving skills. The data results from the validity test using Pearson Product Moment Correlation to see the relationship between the question score and the total score. If the correlation is significant, then the question item is declared valid. While the reliability test is tested using methods such as Cronbach's Alpha. This study uses SPSS Statistics software version 25.0 in the data processing process.

The fourth stage is dissemination; at this stage the effectiveness test is carried out on the students' workbook media that has been developed with the aim of determining the extent to which the students' workbook media is successful in improving students' problem-solving skills. Data collection used 2 classes, namely class VII D which is an experimental class and was given treatment in the form of using students' workbooks, and class VII C, which is a control class and did not receive treatment. In this study, the data collection process was carried out at Junior High School C involving class VII students, each class consisting of 28 students. The study was conducted in six meetings for each class, consisting of one pretest, four learning meetings, and one posttest. In the experimental class, learning was carried out using students' workbooks containing 16 STEAM-real world problem-based activities. Student worked on 4 activities each meeting during four learning meetings, so that all activities in the students' workbook were completed gradually. The activities are designed to train problem-solving skills through observing contextual phenomena, simple experiments, group discussions, and mini projects, such as making a cooler from styrofoam and educational videos about energy efficiency. Meanwhile, in the control class, learning was delivered using conventional methods using teaching modules with the delivery of temperature, temperature scale, expansion, and heat and its transfer, without using student workbooks. This effectiveness test used pretest and posttest questions in which there were problem-solving indicators. The results of the pretest and posttest of both classes were used to collect quantitative data. Analysis of the help of the pretest and posttest results was carried out using SPSS Statistic 25.0 software as an aid. Furthermore, it was analyzed to see the improvement in student problem-solving. The analysis stage carried out first in this study was the equipment test including the normality test used to ensure data distribution and the homogeneity test to determine the differences in variance between classes. Then the Independent Sample t-Test was carried out to determine the differences in the posttest results of the experimental class and the control class. After that, an n-gain test was carried out to measure the effectiveness of student learning in improving understanding of the concept of temperature and heat by using the STEAM-real world problem student's workbook. This test compares the pretest value (before learning) with the posttest value (after learning) to determine the extent of the improvement that has occurred.

3. Research Result

This study develops a product in the form of learning media, namely students' workbook with STEAM-Real World Problem content to improve problem-solving skills of junior high school students in grade VII on temperature and heat material. This students' workbook media is almost the same as student worksheet, but there are a number of advantages, namely this students' workbook is designed according to the independent curriculum for 4 meetings, in the students' workbook there is temperature and heat material combined with various activities that integrate STEAM elements (Science, Technology, Engineering, Arts, and Mathematics) and equipped with problem-solving indicators by Pólya (1973). In addition, this students' workbook is equipped with S-T-E-A-M code icons that appear in each activity, and the appearance of the students' workbook is designed attractively, colorfully, and not monotonously in order to increase interest and the active role of students in learning activities. In Figure 2. The front view of the students' workbook can be seen.

Figurea 2. STEAM integrated students' workbook front page

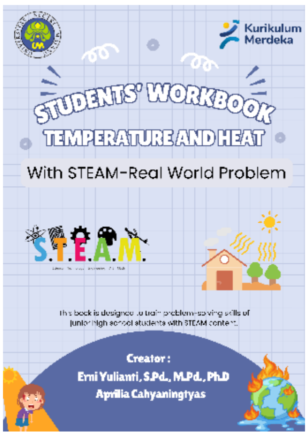


Figure 2. is the cover of the students' workbook used in the research with STEAM-Real World Problem content to improve problem-solving skills. On the front page of the students' workbook there is the title of the material, the author's name, and the approach used. An example of an activity from the students' workbook is in Figure 3.

Figure 3. STEAM Integrated Students' Workbook Activities; (a) S-T-E-A-M Icon Found in Each Activity in the Students' Workbook; (b) Activity (Science) and Problem-solving Practice "Understanding the Problem"; (c) Activity (Technology) and Problem-solving Practice "Understanding the Problem and Making a Plan"; (d) Activity (Engineering) and Problem-solving Practice "Understanding the Problem, Making a Plan, Implementing the Plan, and Rechecking the Results Obtained"; (e) Activity (Arts) and Problem-solving Practice "Implementing the Plan"; (f) Activity (Mathematics) and Problem-solving Practice "Understanding the Problem and Making a Plan"

(a) (b) (c) (d)

(e) (f)

Figure 3 is a STEAM-integrated students' workbook activity used in this study. The students' workbook also contains CP and TP, instructions for use, S-T-E-A-M code icons, and a column for writing students' answers. The questions in the students' workbook encourage students to improve their problem-solving through real-world problems. The steam aspects integrated in this study are shown in Table 3.

Table 3. STEAM Aspects

No.	Aspect	Description	Implementation in Students' Workbook
1	Science	The Science aspect focuses on understanding the natural world through observation, experimentation, and reasoning based on the sciences of physics, chemistry, and biology.	Students conduct observations and experiments on temperature and heat, changes in state, and heat transfer (conduction, convection, radiation) to understand the basic concepts of physics on the topic of temperature and heat.
2	Technology	The Technology aspect focuses on the processes, tools, and knowledge used, developed, and operated in everyday practical solutions.	Students use digital thermometers, temperature sensors, and simulations to understand and visualize heat phenomena. In addition, they also create educational videos using digital technology.
3	Engineering	The Engineering aspect focuses on the ability to design and engineer innovations to solve problems that connect the concepts of science, mathematics, and technology.	Students design and make a simple cooling device to keep the temperature of drinks cold by utilizing the principle of heat transfer.
4	Arts	The Arts aspect focuses on everything about art that can help in finding innovative and creative solutions.	Students create posters about changes in the state of matter and the greenhouse effect, and present the project results in a visually appealing and

No.	Aspect	Description	Implementation in Students' Workbook
			creative way.
5	Mathematics	The Mathematics aspect focuses on the basis of understanding patterns, quantitative relationships, geometric shapes, and the application of mathematical calculations in problem-solving.	Students calculate the amount of heat, temperature changes, and temperature conversions using physics formulas and data analysis.

Source: (Bahrum *et al.* 2017)

After the students' workbook learning media was developed, the next stage was validation. The validity data of the students' workbook that supported this research was conducted by two lecturers of the Science Education Study Program who were experts in the field of physics. This validity test aims to assess the feasibility, quality, and suitability of the learning media before the students' workbook is implemented. In media validity, material validity, the validator assesses each aspect using a 4-point Likert scale, which includes the criteria of "strongly disagree", "disagree", "agree", and "strongly agree", so that the percentage of validity results are obtained for each aspect assessed. Each indicator in the validation sheet is filled in by the validator according to his/her perception of the quality of the aspect being assessed. After the data is obtained, calculations are carried out to obtain the percentage of validity in each aspect. Both validators use a quantitative approach.

Table 4. Media Validity

No	Aspects	Percentage (%)
1	Presentation Feasibility	87.4%
2	STEAM Aspect Accuracy	87%
3	Media Functional Feasibility	85.16%
Average Result		86.52%
Description		Very Valid

The results of the students' workbook media sheet with STEAM-Real World Problem content to improve students' problem-solving skills obtained a validity of 86.52% as seen from table 4, including the very valid category. From the results of the media validity, the students' workbook is suitable for use in learning activities, as explained by (Akbar, 2016). In addition, the validator also provided general notes that the students' workbook product was good and could be tested without revision.

Table 5. Material Validity

No	Aspects	Percentage (%)
1	Suitability of Material	91.33%
2	Relevance of Source Material Used	87.25%
3	Truth of Concept	100.00%
Average Result		92.86%
Description		Very Valid

The results of the validation at Table 5 show that the students' workbook media with STEAM-Real World Problem content to improve students' problem-solving skills obtained a validity of 92.86% with a very valid category. Thus, the students' workbook that was developed has met the eligibility standards as a learning medium, in accordance with the assessment criteria put forward by (Akbar, 2016). In addition, the validator also provided a general note that the students' workbook product was good and could be tested without revision.

Table 6. Problem-solving Skills (PSS) Validity

No	Aspects	Percentage (%)
1	Problem-solving Skills	100.00%
Average Result		100.00%
Description		Very Valid

The results of the validation on Table 6 of the Problem-solving Skills (PSS) aspect using the Guttman scale, from 32 statements all were stated as "Yes" by the validator, so that the validity score was 100.00%. This means that the contents of the activities and indicators that have been developed are in accordance with Pólya's theory (1973), relevant to the STEAM approach, and support students' problem-solving skills in temperature and heat material. Based on the eligibility criteria, the results of 100.00% indicate that the problem-solving Skills indicator in the students' workbook is declared very valid. This shows that the students' workbook that was developed has met the eligibility criteria for use in learning, as the assessment criteria explained by (Akbar, 2016). In addition, the validator also provided a general note that the students' workbook product was good and could be tested without revision.

The students' workbook learning media with STEAM-Real World Problem content, after being declared valid by experts, was then tested on teachers and students, through a readability test. The readability test was conducted at Junior High School B, involving 2 science teachers and 10 students. The purpose of the readability test was to determine the extent to which the students' workbook learning media can be easily understood by students and effectively used in learning. Students were given time to read the contents of the students' workbook before being given a validation sheet. After that, students filled out the readability test validation sheet (students). The results of the student readability test showed that all students stated that the students' workbook was easy to understand and they could follow the activity instructions well. Both teachers also said that the students' workbook was suitable for use in the learning process, with the note that each activity was given an activity/activity title, or the purpose of the activity was written, the choice of language that was easy for students to understand, and it was necessary to understand the difference between objectives and indicators.

In addition to developing students' workbook learning media, researchers also developed pretest posttest questions using Polya's problem-solving indicators in the form of descriptive questions consisting of 8 questions. The development of these questions aims to improve problem-solving before and after learning using students' workbooks. Before the pretest posttest question instrument is used for the effectiveness test, a validity and reliability test is first conducted. The empirical test was conducted at Junior High School B in class 7C with 28 students. The results of the empirical test were in the form of Pearson Bivariate correlation results (validity test) and Cronbach's Alpha (reliability test).

Based on the results of the validity analysis conducted using Pearson's Bivariate correlation on the questions developed, namely 8 questions. It was found that all questions were declared valid. This is based on the results of the calculated r of each question being greater than the r table (0.388) or the significance result being less than 0.05. Furthermore, a Cronbach's Alpha reliability test was conducted. The results of the reliability test on 8 valid questions were 0.665, which is included in the high reliability category. These results indicate that the 8 questions meet the requirements for use and are suitable for use in research.

Before testing the effectiveness of the product, prerequisite tests are carried out first, namely normality tests and homogeneity tests. Table 7 presents the results of the normality test and Table 8 presents the results of the homogeneity test.

Table 7. Results of the Normality Test Pretest Posttest Experimental and Control Classes

Class	Shapiro-Wilk Test		
	Sig. Level	**Sig.**	**Conclusion**
Experiment Pretest	0.05	0.122	Normal
Experiment Posttest	0.05	0.164	Normal
Control Pretest	0.05	0.482	Normal
Control Posttest	0.05	0.363	Normal

Based on the results of Table 7, all significance values (Sig.) in the Shapiro-Wilk test on each pretest posttest data of both classes are >0.05. From these results, all data are normally distributed

Table 8. Results of the Homogeneity Test for the Pretest Posttest of the Experimental and Control Classes

Class	Levene Test		
	Sig. Level	**Sig.**	**Conclusion**
Pretest experiment control	0.05	0.897	homogeneous
Posttest experiment control	0.05	0.958	homogeneous

Based on the results of Table 8, the significance value (Sig.) of the pretest-posttest data for both classes is more than 0.05, indicating that the variance of both classes is homogeneous.

Independent Sample t-Test

The next stage, after the prerequisite test has been fulfilled, is to conduct an effectiveness test using the independent sample t-test to see the differences between classes that use students' workbooks and those that do not.

Table 9. Result Independent Sample t-Test

Class	Different Test		
	Sig. Level	Sig. (2-tailed)	Conclusion
Pretest experiment control	Sig. >0.05	0.068	equal initial ability
Posttest experiment control	Sig. <0.05	0.000	different final ability

Table 10. Result Compare Mean Test

Result Posttest		N	Mean
Experiment Class		28	64.75
Control Class		28	14.25

In the results of Table 9. shows the results of the independent sample t-Test on the pretest data with a Significance value (2-tailed) of 0.068> 0.05, this indicates that there is no significant difference between the two classes. Based on these results, it can be concluded that students have the same initial abilities, as expected in the experimental design. Therefore, the pretest data was not used in further analysis. Meanwhile, the results of the t-test on the posttest data obtained a Significance value. (Sig. 2-tailed) of 0.000, less than 0.05. Thus, it can be concluded that there is a significant difference between the two classes. In the results of Table 10. Shows that the posttest results of the experimental class (students' workbook) obtained a mean of 64.75, while in the control class (without students' workbook) obtained a mean of 14.25. Therefore, the use of students' workbooks has a very positive impact on improving student learning outcomes.

Table 11. Result N-Gain Test

N-gain Test		N-gain Percent	Category
Experiment Class		61.81%	Significant improvement

Referring to the results of Table 11. the average value (mean) of N-gain using SPSS in the class given the students' workbook treatment was 61.81% indicating a significant increase according to Hake in A.A. Setyo *et al.* (2022). The use of students' workbooks has been proven to be significant in improving the problem-solving skills of junior high school students in the material of temperature and heat. In Figure 4. It can be seen that all problem-solving indicators have increased after being given the students' workbook treatment. The indicator that experienced the highest increase was the "implementing planning" indicator, where the pretest result percentage was 8.81, while during the posttest it increased significantly to 68.19, so that it increased by 674%. Thus, these results can prove that students are able to implement the indicators well, so that they can experience significant improvement. This increase is in line with learning activities using students' workbooks. In addition, activities in students' workbooks can not only train students in improving their problem-solving skills, but also to integrate STEAM elements in real terms. Through activities in the students' workbook, students are invited to apply science in understanding concepts, technology in compiling and implementing solutions, art in expressing creative ideas, and mathematics in calculations. As shown in Figure 5. Some activities in the students' workbook that are done by students.

Figure 4. Improvement in Pretest and Posttest Results for Each Indicator in the Experimental Class

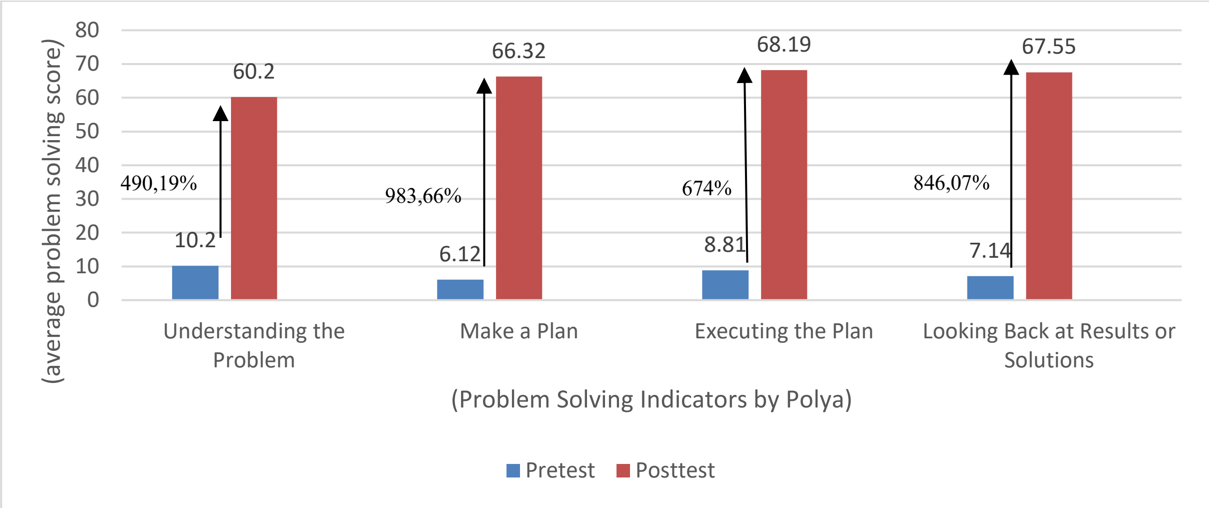
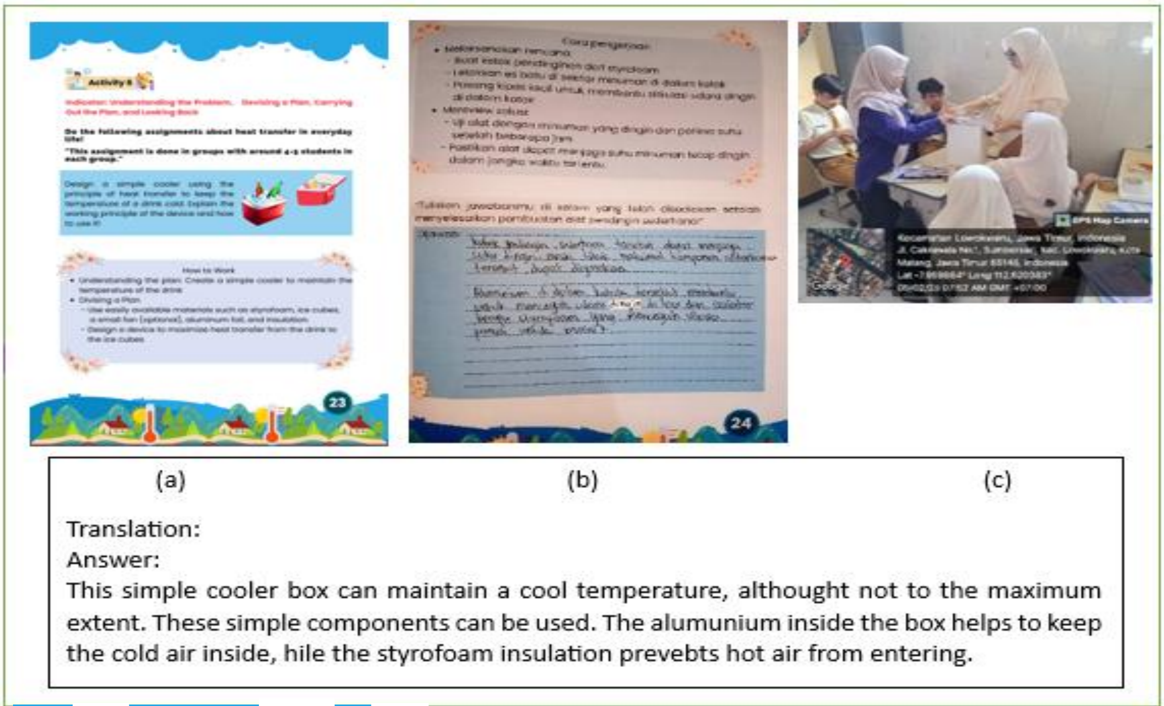
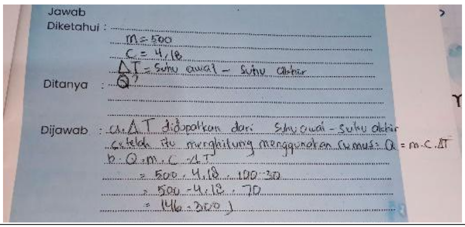


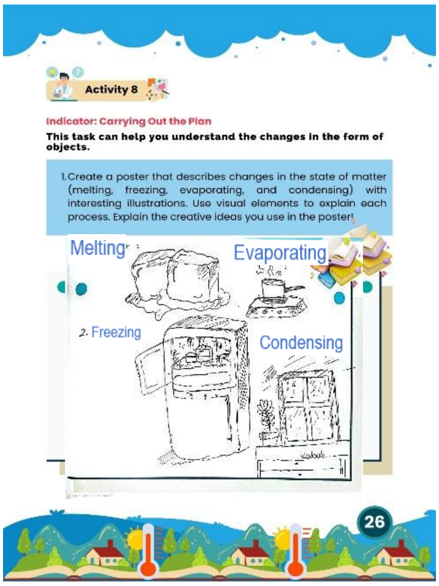
Figure 5. Several Students' Workbook Activities Towards Indicator Improvement; (a) Engineering Activities; (b) Students' Answers to the STEAM (Engineering) Aspect and Problem-solving Indicator "Understanding the Problem, Making a Plan, Carrying Out the Plan, and Rechecking the Results Obtained"; (c) Students' Process of Making Cooling Devices; (d) Students' Answers to the STEAM (Arts) Aspect and Problem-solving Indicator "Carrying Out the Plan"; (e) Students' Answers to the STEAM (Science) Aspect and Problem-solving Indicator "Understanding the Problem, Making a Plan, and Carrying Out the Plan".





(d) (e)

Translation:
Answer:
Known: m= 500
C= 4,18
ΔT= Intial temperature – final temperature
Asked: Q?
Answered:
a. ΔT obtained from intial temperature – final temperature after that calculate using formula Q= m.c. ΔT
b. Q= m.c. ΔT
500.4,18.100-30= 500-4,18.70=146.300 J



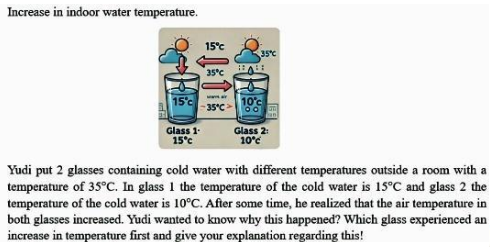
(e)

Based on the results of Figure 4. It is concluded that students' workbook is more effective in improving students' problem-solving skills than before using students' workbook. The low pretest means that students' problem-solving skills are lacking. However, after learning in the experimental class using students' workbook to improve students' problem-solving skills, there was an increase in scores (posttest). The following is a detailed explanation of students' answers to each indicator.

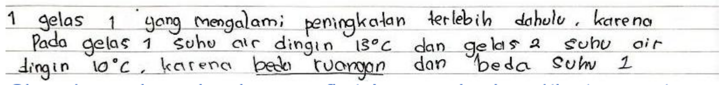
1.Understanding the problem

In the indicator of understanding the problem, the aspect that is emphasized is the students' skills in identifying important information from the problem expressed in the question. Students are given reading questions about increasing the temperature of water in a room. Based on the reading, students are asked to explain which glass experiences an increase in temperature first in the two glasses that have different temperatures outside the room with a temperature of 35°C and provide reasons. The appearance of the questions and answers for the students' pretest and posttest can be seen in Figure 6.

Figure 6. (a) Pretest and Posttest Questions on the Understanding Problem Indicator; (b) Students' Pretest Answers on the Understanding Problem Indicator; (c) Students' Posttest Answers on the Understanding Problem Indicator.

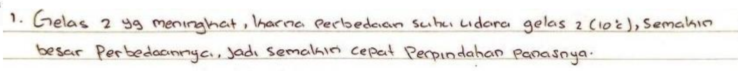


(a)



Glass 1 experienced an increase first, because in glass 1the temperature of the cold water was 15°C and in glass 2 the temperature of the cold water was 10°C, because of the different rooms and different temperatures.

(b)



Glass 2 increases, due to the difference in air temperature between glass 2 (10°C), the greater the difference, the faster the heat transfer.

(c)

It can be seen that the students' answers in Figure 6 (b), it appears that the students have not been able to understand the problem correctly. The students answered that glass 1 experienced an increase first, while the correct answer is glass 2, because it has a larger temperature difference with the room temperature, so it quickly receives heat. This shows that students do not understand the concept of heat transfer. In the posttest section with the same indicators and the same questions. It can be seen that the students' answers in Figure 6 (c) are able to provide the right answer. Based on the question about the increase in water temperature in two glasses, the students answered that glass 2 experienced an increase in temperature first because it had a larger temperature difference with the room temperature. This answer is correct and shows that students have focused on the question and understand the concept of heat transfer correctly.

The students' workbook activity that directly supports the improvement of the problem understanding indicator is Activity 7. There is a STEAM (Science) aspect. In this activity, students are asked to observe the phenomenon of changes in the state of objects and identify the types and causes. This activity can train students to recognize important information from the situation and understand the concept of heat transfer, as required in the problem understanding indicator according to Polya. The display of activity 7 and students' answers are attached in Figure 7.

Figure 7. Students' Workbook Activity Indicator Understanding Problems And Students' Answer

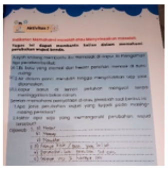


Figure 7. Students' Workbook Activity Indicator Understanding Problems and Students' Answers

Aisyah is helping her mother cook in the kitchen. She observes the following three events:

1. The ice cubes taken from the freezer slowly melt at room temperature.
2. The water in the pot boils and emits steam when heated.
3. The camphor in the closet slowly shrinks without leaving any liquid residue.

After understanding the above statement, answer the following questions:

1. What type of change of state occurs in each event?
2. What factors influence these changes?

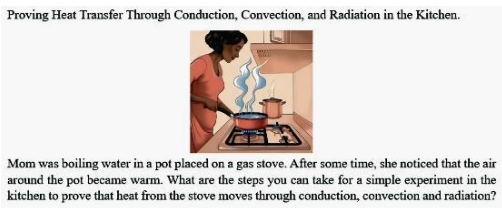
Answer:

1. a) Melting 2. a) The presence of heat or heat involved
b) Evaporate b) Heating, surface area of liquid
c) Sublimate c) Vapor pressure and temperature relationship

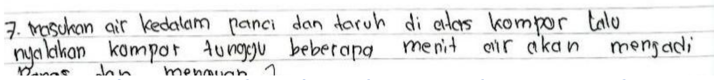
2. Making a Plan

In the indicator of making a plan, the aspect highlighted is the students' skills in designing simple experiments to prove heat transfer through conduction, convection, and radiation in a kitchen environment. In this case, students are expected to be able to arrange the steps in a sequential, logical, and easy-to-understand manner. Students must also be able to clearly identify the parts of the experiment that show each heat transfer. The appearance of the students' pretest and posttest questions and answers can be seen in Figure 8.

Figure 8. (a) Pretest and Posttest Questions on the Planning Indicator; (b) Students' Pretest Answers on the Planning Indicator; (c) Students' Posttest Answers on the Planning Indicator.

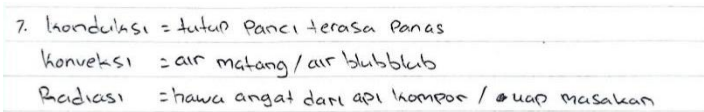


(a)



Put water in a pan and put it on the stove, then turn on the stove, wait a few minutes, the water will become hot and evaporate.

(b)



Conduction = the lid of the pan feels hot
Convection = boiled water / blubblub water
Radiation = warm air from the stove / cooking steam

(c)

It can be seen that the students' answers in Figure 8 (b), it appears that the students have not been able to link the heat transfer process specifically through conduction, convection, and radiation, and have not mentioned the parts involved in each process. This shows that students still do not understand the concept of heat transfer as a whole. It can be seen that the students' answers in Figure 8 (c), have been able to provide the right answer. Students have been able to explain which parts are involved in each type of heat transfer. This shows an increase in understanding the concept and linking the phenomena that occur with the right concept of heat transfer. This reflects problem-solving skills that are starting to develop through learning that involves analysis of everyday phenomena.

The relevant students' workbook activity to improve the planning indicator is activity 9. There is a STEAM (Mathematics) aspect. In this activity, students are asked to design the solution steps and calculate the temperature changes based on the mass data, specific heat, and heat received by the object. This activity is in line with the planning indicator according to Polya, because it encourages students to determine the solution strategy by choosing the appropriate formula. The display of activity 9 and students' answers are attached in Figure 9.

Figure 9. Students' Workbook Activity Indicator for Preparing Students' and Students' Answer

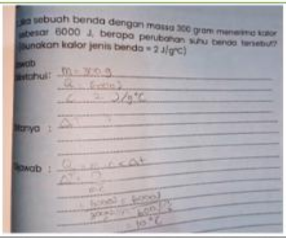


Figure 9. Students' Workbook Activity Indicators for Preparing Students' Plans and Answers

Question:

If an object with a mass of 300 grams receives 6000 J of heat, what is the change in temperature of the object? (Use the specific heat of the object = 2 J/g°C)

Answer:

Known: m= 300 g

Q= 6000 J

C= 2J/g°C

Asked: Δ?

Answered: Q= m.c.ΔT

$$\Delta T = \frac{Q}{m.c} = \frac{6000\,J}{3000 \times 2J/g^{\circ}C} = \frac{6000\,J}{600\,J/^{\circ}C} = 10^{\circ}C$$

3. Implementing Planning

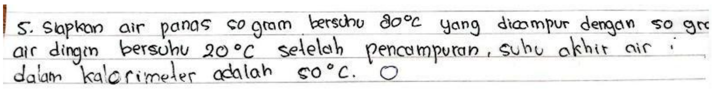
In the implementing planning indicator, the aspect that is emphasized is that students are asked to apply formulas and calculation strategies to solve problems. Students are given questions about mixing 50 grams of hot water at a temperature of 80°C with 50 grams of cold water at a temperature of 20°, the final temperature is recorded as 50°C. The appearance of the questions and answers for the pretest and posttest of students can be seen in Figure 10.

Figure 10. (a) Pretest and Posttest Questions on the Implementing Planning Indicator; (b) Students' Pretest Answers on the Implementing Planning Indicator; (c) Students' Posttest Answers on the Implementing Planning Indicator

Testing the Principle of Heat Balance in the Calorimeter Experiment.

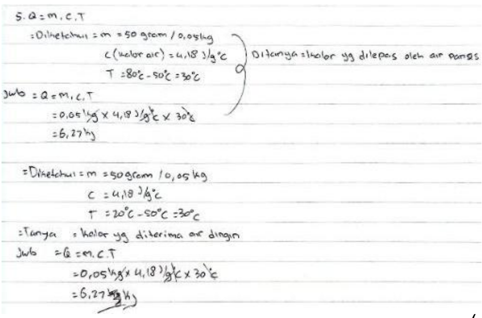
Haris will conduct an experiment with a calorimeter. Measuring the heat of 50 grams of hot water at 80°C mixed with 50 grams of cold water at 20°C. After mixing, the final temperature of the water in the calorimeter is 50°C. Explain whether this result is consistent with the principle of heat balance and how to check the result of the experiment?

(a)



Prepare 50 grams of hot water at a temperature of 80°C mixed with 50 grams of cold water at a temperature of 20°C. After mixing, the final temperature of the water in the calorimeter is 50°C

(b)



(c)

Q= m.c.ΔT

Known: m= 50 gram/0,05 kg

c (kalor air)= 4,18 J/g°C

T= 80°C-50°C= 30°C

Asked= heat released by hot water

T= 80°C-50°C= 30°C

Answer: Q= m.c.ΔT

= 0,05 kg x 4,18 J/g°C x 30°C

= 6,27 kj

Known= m= 50 gram/0,05 kg

c (kalor air)= 4,18 J/g°C

T= 20°C-50°C= 30°C

Asked= heat received by cold water

Answer= Q= m.c.T

= 0,05 kg x 4,18 J/g°C x 30°C

= 6,27 kj

It can be seen that the students' answer in Figure 10 (b), it that the students has not been able to carry out the calculation planning to prove the accuracy of the date. The student only answered the final temperature without calculation. It can be seen that the students' answer in Figure 10 (c), has been able to provide the correct answer. The student has been able to calculate the heat released by hot water and absorbed by cold water using the formula Q= m x c x ΔT, and get the heat value (6.27 kJ), indicating that the student has succeeded in carrying out the calculation planning correctly and concluded that the results are in accordance with the principle of heat balance.

The relevant students' workbook activity in improving the indicator of implementing the plan is Activity 10. There is a STEAM (Technology) aspect. In this activity, students are asked to analyze how technology in cooking utensils can increase the efficiency of heat transfer, and explain how it works. This activity trains students to apply conceptual knowledge about heat transfer. The display of activity 10 and student answers are attached in Figure 11.

Figure 11. Students' Workbook Activity Indicator Implementing Planning and Students' Answer

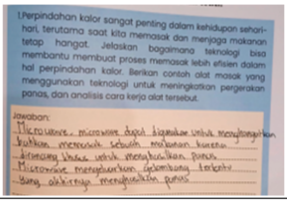


Figure 11 Students' Workbook Activity Indicator Implementing Planning and Students' Answer

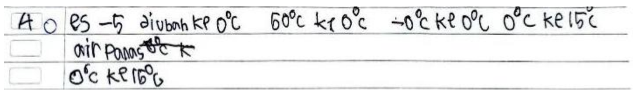
Question:
Heat transfer is very important in everyday life, especially when we cook and keep food warm. Explain how technology can help make the cooking process more efficient in terms of heat transfer. Give examples of cooking appliances that use technology to improve heat transfer, and analyze how these appliances work.
Answer:
Microwave ovens can be used to heat and even cook food because they are specifically designed to generate heat. Microwave ovens emit certain waves that ultimately generate heat.

4. Looking Back at Results or Solutions

In the indicator of looking back at results or solutions, the aspect that is emphasized is that students are expected to be able to review the steps of the solution to ensure the correctness of the solution obtained. In this activity, the question instructions encourage students to reflect on the results of the experiments they have done related to heat transfer in everyday life, especially in keeping the temperature of drinks cold. The appearance of the questions and answers for the pretest and posttest of students can be seen in Figure 12.

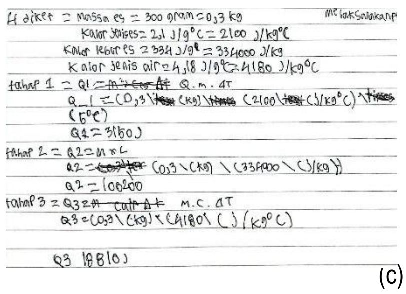
Figure 12 (a) Pretest and Posttest Questions on the Looking Back at Results or Solutions Indicator; (b) Students' Pretest Answers on the Looking Back at Results or Solutions Indicator; (c) Students' Posttest Answers on the Looking Back at Results or Solutions Indicator.

(a)



ice -5 changed to 0°C 60°C to 0°C -0°C to 0°C 0°C to 15°C
hot water
0°C ke 15°C

(b)



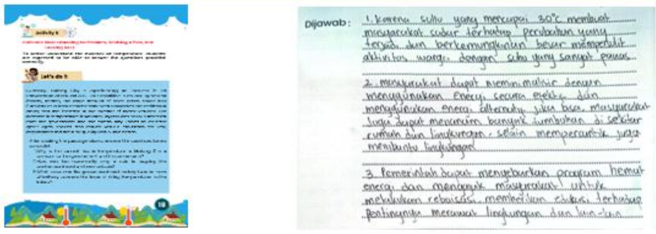
Known= mass of ice = 300 grams= 0,3 kg
specific heat capacity = 2,1 J/g°C= 2100 J/kg°C
heat of fusion of ice. = 334 J/g= 334000 J/kg
specific heat capacity of water = 4,18 J/g°C= 4180 J/kg
Stage 1= Q1= Q.m.Δ T
Q1= (0,3 (kg) (2100 J/kg°C) (5°C)
Q1= 3150 J
Stage 2= Q2= m x L
Q2= (0,3 kg) (334000 J/kg)
Q2= 100200
Stage 3= Q3= m.c.ΔT
Q3= (0,3 kg) (4180 J/kg°C)
Q3= 18810 J

(c)

It can be seen that the students' answers in Figure 12 (b), it appears that the students have not been able to evaluate each calculation step correctly, so that errors occur in solving problems, such as errors in using formulas or stages of the process of changing the state of matter. This shows that the students' ability to reflect on the resulting solution is still lacking. It can be seen that the students' answers in Figure 12 (c). have been able to compile the energy calculation stages correctly, recheck the final results, and ensure the appropriateness of the calculation steps. This indicates an increase in students' ability to review the results of the solution as part of good problem-solving skills.

The students' workbook activity that supports the improvement of indicators looking back at results or solutions is Activity 5. There is a STEAM (Science) aspect. In this activity, students are asked to evaluate the causes of the increase in temperature in Malang City and formulate steps that can be taken by the community and government to overcome it. This activity encourages students to review the solutions that have been made and consider their effectiveness, according to the indicator, namely the ability to evaluate the steps of the solution and ensure the truth and feasibility of the solution taken. The display of activity 5 and student answers are attached in Figure 13.

Figure 13. (a) Activity 5 Qustions; (b) Students Answer in Activity 5



(a) (b)

Figure 13. (a) Activity 5 Questions; (b) Student Answers in Activity 5

Answer:

1. Because the temperature reaches 30°C, it makes people aware of the changes that occur and is likely to reach citizen activities with very hot temperatures.
2. The community can minimize by using energy effectively and using alternative energy if possible, the community can also plant many plants around the house and the environment, in addition to beautifying it also helps the environment.
3. The government can spread energy saving programs and invite the community to reforest, provide education on the importance of caring for the environment and others.

Based on the analysis above, it shows that the instrument used is able to improve problem-solving skills appropriately and consistently through the results of validity and reliability tests. Valid and reliable instruments are very important to ensure that the improvement in student learning outcomes truly reflects the influence of learning, not because of the inaccuracy of the measuring instrument (Sharma *et al.* 2024).

The results of the analysis have also strengthened the objectives of the study that have been explained previously, namely to improve students' problem-solving skills through the use of students' workbooks with STEAM-Real World Problem content. In line with the statement of Bessas *et al.* (2024), students are expected to be able to master 21st century skills, especially in the aspects of critical thinking and problem-solving. The use of students' workbooks with STEAM-Real World Problem content in this study has been proven to be able to facilitate the development of these skills significantly.

These results also support the urgency explained earlier that the problem-solving skills of Indonesian students are still relatively low (OECD, 2023), so contextual and structured learning media are needed such as in the STEAM approach. The students' workbook media developed not only provides an understanding of temperature and heat material but also provides space for students to develop creativity and critical thinking through solving real problems (Yakman, 2008). This statement is in line with research stating that the experimental class using students' workbooks experienced a higher increase in problem-solving skills than the control class.

The use of students’ workbooks with STEAM-Real World Problem content in learning temperature and heat material has a stronger influence in improving students’ problem-solving skills compared to classes that do not use students’ workbooks. The advantages of this students’ workbook lie in the integration of problem-solving activities involving elements of science, technology, engineering, art, and mathematics, as well as their relevance to the context of real-world problems. This statement is in line with Yakman (2008), who emphasized that the STEAM approach supports cross-disciplinary integration and encourages the improvement of critical and analytical thinking skills through active involvement in solving problems related to everyday life.

Conclusion

The results of the needs analysis obtained through interviews with teachers and students of grade VII of junior high school, as well as through the distribution of questionnaires to grade VIII students, identified that teachers need additional media in the form of student workbooks to facilitate the improvement of students' problem-solving abilities on temperature and heat materials and junior high school students also need additional learning media in the form of student workbooks with STEAM-real world problem content to help them improve their problem-solving abilities on temperature and heat materials. Researchers have succeeded in developing student workbooks with STEAM-Real World Problem content for junior high school students on the topic of temperature and heat to improve problem-solving abilities that are valid and suitable for use in the learning process, based on the validation results by material experts and media experts. The validation results by media experts obtained an average score of 86.52% which is included in the valid category, while the validation results by material experts obtained an average score of 92.86% and is included in the very valid category. Based on the results of the N-Gain test that has been conducted, it was obtained that student workbooks with STEAM-Real World Problem content are effective in improving students' problem-solving abilities on temperature and heat materials. These results, proven through instrument validity and reliability tests, obtained that the pretest and posttest questions have met the requirements as a good measuring tool. The increase in problem-solving ability is shown by the N-Gain value of the Experimental class of 61.81%, indicating a significant increase. This study is a student workbook development study that applies problem-solving stages to temperature and heat material and integrates STEAM aspects in it, which is proven to help students understand physics concepts and relate them to real-life problems. This study also enriches physics learning strategies and improves junior high school students' problem-solving abilities.

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Credit Authorship Contribution Statement

Aprilia Cahyaningtyas: Responsible for gathering and processing the data, organizing figures and tables, as well as assisting in interpreting the findings.
Erni Yulianti: Designed the research framework, formulated the methodology, and provided supervision throughout the study.
Fatin Aliah Phang: Composed the manuscript, carried out critical revisions for substantial academic quality, and completed the final submission.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declane that they have not used generative AI dan AI-assisted technologies during the preparation of this work

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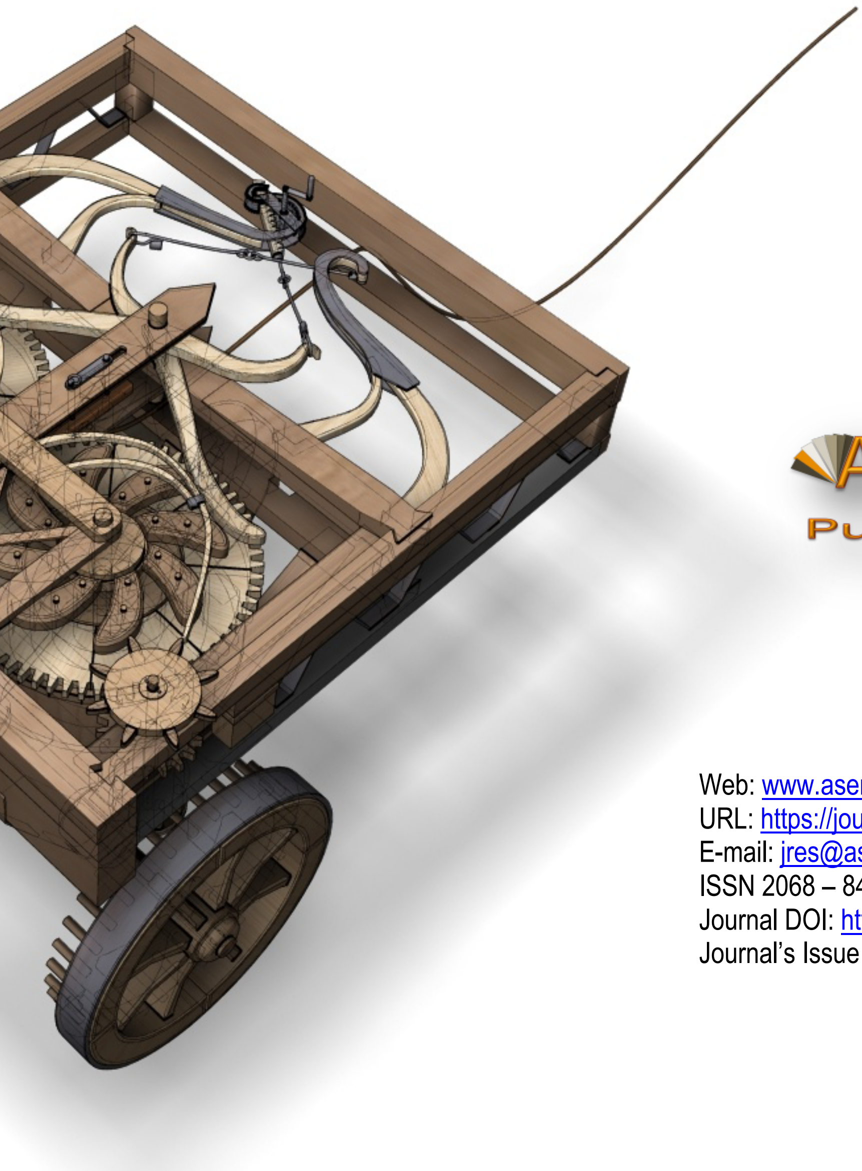

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