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Improving Students' Problem-Solving Skills Using Direct Instruction-Oriented Worksheets on the Subject of Temperature and Heat

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Abstract

Problem-solving skills are among the key competencies in 21st-century life, yet they are poorly trained in schools. This study aims to produce a direct teaching-oriented temperature and heat worksheet that is feasible to use to improve students' problem-solving skills. The ADDIE design was used in the development of this worksheet. The worksheet was tested on 25 students in Class XI SMA. Data was measured using validation instruments, response questionnaires, and problem-solving tests. The results showed that the developed student worksheet was categorized as very valid, the student's response to using the worksheet was categorized as practical, and the student worksheet was categorized as effective because the N-Gain of problem-solving of 0.56 was categorized as moderate. This means that the developed direct teaching-oriented student worksheet is feasible to improve problem-solving skills. This student worksheet can be an alternative for teachers to equip 21st-century competencies, especially problem-solving skills.

Keywords: Direct Instruction; Problem-Solving Skills; Temperature and Heat; Worksheet

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INTRODUCTION

In the era of Industry 4.0, problem-solving skills are crucial in facing various opportunities and challenges in an increasingly complex life (Rony et al., 2020; Zubairi et al., 2022). Problem-solving skills involve an individual's thought process in resolving issues through a series of systematic steps (Maulidia, 2019; Santrock, 2011). This relates to understanding how to tackle problems, adeptly selecting relevant concepts and principles, identifying solutions, and taking appropriate actions to overcome difficulties (Asfar & Nur, 2018; Smith et al., 2022).

In introducing physics to students, the goal is for them to comprehend the fundamental principles and develop proficiency in applying the scientific method based on a scientific mindset (Werth et al., 2022; Zulyusri et al., 2022). Students should be capable of applying their knowledge to solve problems within the realm of physics (Hariyani et al., 2022; Sambada, 2012). According to Susiana et al. (2017), physics learning is more effective when it involves independent problem-solving in physics. This way, students can gain a robust understanding and confidence in developing the skills necessary to tackle various challenges in physics (Werth et al., 2022). According to Martaningsih et al. (2022) and Thersia et al. (2019), to address physics problems, students must have a profound mastery of the subject matter and apply it in relevant contexts, following the guidelines.

Students with weak problem-solving skills may tend to rely on memorization in learning physics, according to studies by Alsarayreh (2023), Assem et al. (2023), Burkholder et al. (2023), Efendi (2022), Gjerde et al. (2022), and Saiful (2023). This can make it difficult for them to solve physics problems effectively. The study by Rahimah et al. (2021) revealed that students in a public high school in Banjarmasin still face challenges completing assigned physics tasks. Many appear confused, especially when explaining the context of the given questions. Thersia et al. (2019) found that only 14% of 10th-grade students in a science high school in Banjarmasin had trouble describing events, identifying known and unknown variables, and pinpointing the appropriate equations. The initial study further supports this, as interviews with physics teachers revealed that students have a limited grasp of problem-solving skills. Students struggle to complete the problems provided by teachers through the stages of problem-solving skills, ranging from describing the problem, defining the problem in physics terms, planning a solution, and implementing a solution to evaluation.

Various efforts need to be made to equip students with problem-solving skills, one of which is the development of a Direct Instruction-Oriented student worksheet. According to Maulidia (2019), the use of student worksheets is highly suitable in the process of learning physics. Direct instruction has enhanced students' problem-solving skills (Izzati et al., 2020). The advantage of the student worksheet is that it includes videos and images to assist students in understanding the material and solving problems. This research aims to assess the effectiveness of student worksheets in teaching physics, specifically in terms of how well they help students develop problem-solving skills to tackle physics problems.

METHOD

This study follows a research and development approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The research subjects were 25 11th-grade science students from one of the high schools in Banjarmasin. The research focuses on direct instruction-oriented student worksheets. The research instruments include a validation sheet for the student worksheet, a questionnaire for student responses, and a problem-solving test sheet. Before use, the student worksheet was validated by two physics education experts and one physics learning practitioner. The validity score was determined according to the criteria: not valid ≤ 1.6; $1.6 <$ not quite valid ≤ 2.2; $2 <$ fairly valid ≤ 2.8; $2.8 <$ valid ≤ 3.4; and $3.4 <$ highly valid (Suyidno et al., 2020). Additionally, the reliability of the student worksheet was calculated using the Cronbach's alpha formula with the following criteria: $0.0 \leq$ very low < 0.2; $0.2 \leq$ low < 0.4; $0.4 \leq$ fair < 0.6; $0.6 \leq$ high < 0.8; and $0.8 \leq$ very high < 1.0 (Arikunto, 2015).

The feedback from the validators serves as consideration for the researcher to revise the Direct Instruction-Oriented student worksheets. Following this, a classroom trial using a one-group pretest-posttest design (O1 x O2) will be conducted. The learning process would commence by administering a pre-test on problem-solving skills to the students (O1). Subsequently, the student worksheet was implemented in three sessions (X), followed by a post-test on problem-solving skills (O2).

The students' response scores are categorized according to the following criteria: 0 < not practical ≤ 40; 40 < less practical ≤ 55; 55 < fairly practical ≤ 65; 65 < practical ≤ 80; and 80 < highly practical < 100 (Adapted from Suyidno et al., 2022). Additionally, the data from the pre-test and post-test on problem-solving skills are analyzed using the n-gain score, and the values are then assessed based on the criteria: high > 0.7; 0.7 ≥ moderate ≥ 0.3 and low < 0.3 (Hake, 1998).

RESULT AND DISCUSSION

The feasibility of the student worksheet product is evaluated based on its level of proficiency in meeting the standards set by the National Professional Certification Agency. The developed product, presented as a student worksheet, is outlined in Figure 1.

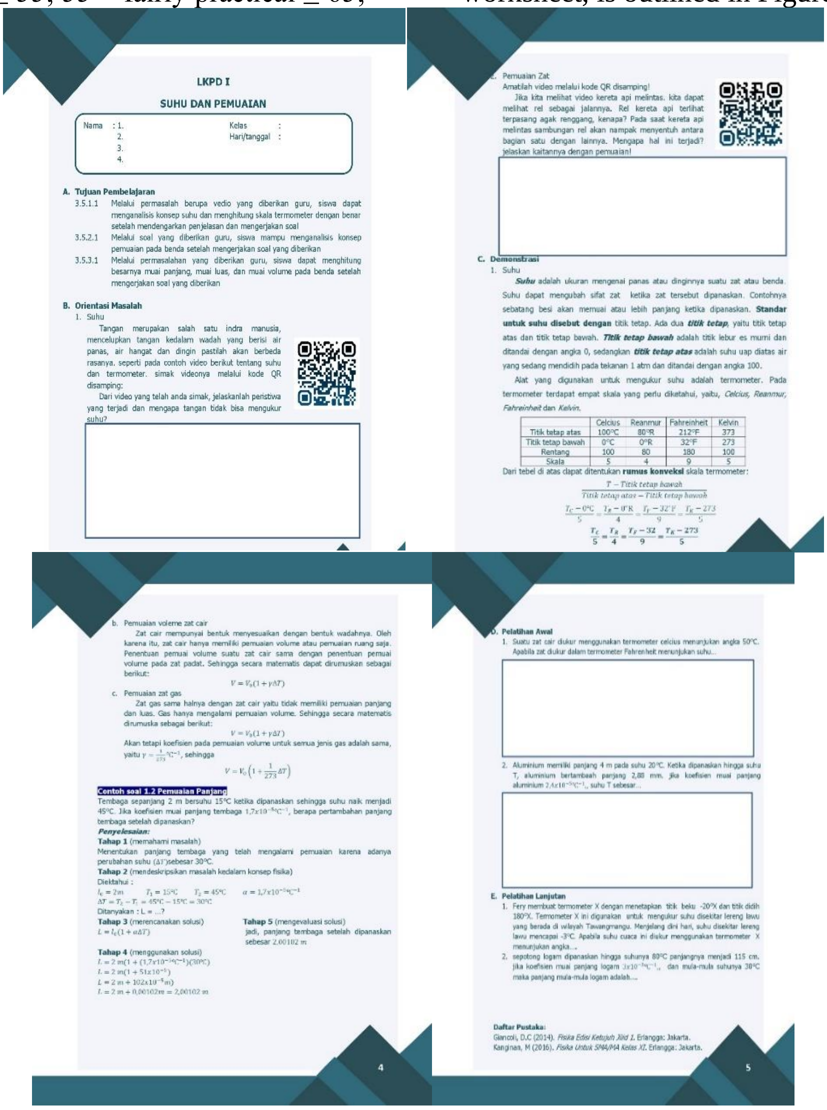

Figure 1 Display of worksheet

Seels and Richey, as cited in Sutarti & Irawan (2017), state that the developed product's feasibility should meet valid, practical, and effective criteria.

The Validity of the Student Worksheet

The assessment of the validity of the student worksheet aims to determine the suitability of its content and construct. This validation instrument encompasses standard points of feasibility that the student worksheet should possess to be deemed suitable for use. The student worksheet is adjusted by considering the aspects to be measured: problem-solving skills. The results of the student worksheet validation test can be seen in Table 1.

Table 1 The result of the validity of the student worksheet

Aspect of Review	Average	Category
Didactic	3.58	Highly valid
Construction	3.42	Highly valid
Technique	3.28	Valid
KPM	3.67	Highly valid
Validity	3.46	Highly valid
Reliability	0.84	High

Based on Table 1, the validity of the student worksheet meets four aspects of validity: didactic, construction, technique, and problem-solving skills.

The Direct Instruction-Oriented student worksheet on Temperature and Heat includes teaching phases that help students practice problem-solving using the Heller procedure. This approach allows students to learn directly from the teacher, enhancing their understanding and problem-solving skills (Cashata et al., 2023; Serevina et al., 2022). The direct teaching approach enables students to learn directly from the teacher about the current topic being discussed, as well as physics problem-solving techniques, in order to develop both declarative knowledge and procedural skills (Cashata et al., 2023; Serevina et al., 2022).

When creating the Direct Instruction-Oriented student worksheet on Temperature and Heat, it's important to organize it logically, systematically, and in a way that relates to the student's cognitive progression. The language, sentence structure, and difficulty level should be adjusted to match the student's abilities (Trimulyono, 2023).

In terms of technique, the student worksheet has considered the writing, images, and overall layout to effectively convey the message or content to the users, making it easier for students to complete tasks. Regarding the KPM aspect, the design of the student worksheet is structured to enable students to solve physics problems by following the specified steps (Karuru & Kabanga, 2023). This helps students understand how problem-solving skills can be applied in the context of the subject matter being studied (Djudin, 2023).

The Direct Instruction-Oriented student worksheet on temperature and heat is rated highly valid in all four aspects. Meanwhile, the average rating for reliability falls into the high category. This conclusion indicates that the Direct Instruction-Oriented student worksheet on Temperature and Heat can effectively develop students' problem-solving skills in learning about temperature and heat.

The Practicality of the Student Worksheet

The practicality of the student worksheet with a direct teaching orientation was assessed based on student response questionnaires, and the results are summarized in Table 2.

Table 2 The practicality of the student worksheet's result

Aspect of Assessment	Average	Category
Attractiveness	80	Practical
Easy to use	76	Practical
Content	74	Practical
Average	76	Practical

Based on Table 2, the average practicality score obtained falls into the "practical" category. The results from the student response questionnaire indicate that the worksheets are perceived as attractive, easy to use, and relevant to the material and learning objectives.

From the attractiveness perspective, worksheets are crucial in enhancing learning motivation. Engaging worksheets facilitate students in delving deeper into the process of learning physics and heightens their enthusiasm for the subject. When individuals feel engaged in learning, they tend to be more active and participate more effectively. Judging by the aspect of attractiveness, the worksheets can be categorized as practical, as most students demonstrate interest and active involvement in the learning process involving these worksheets.

From the perspective of ease of use, using worksheets is a crucial factor in enhancing learning effectiveness. These worksheets make it easier for students to grasp the material in the physics class. The ease of using student worksheets can minimize learning barriers and improve learning efficiency (Frisilla & Hardeli, 2022; Maulidiya & Mercuriani, 2023). Judging by the aspect of ease of use, these worksheets can be categorized as practical, as students, on average, find them easy to use. This means that students can understand the physics material presented through these worksheets.

Regarding the content aspect, worksheets are a crucial factor in improving the quality of physics learning. The relevance of the content in the worksheets to the material and learning objectives makes it easier for students to understand the physics material (Dewitasari & Rusmini, 2023; Marlina & Wiyono, 2022). Appropriate and relevant content in the worksheets would facilitate the learning process and enhance the quality of learning. Judging by the content aspect, these worksheets can be categorized as practical, as students generally feel that the content in the worksheets aligns with the learning objectives and helps them understand the physics material. This means that, when evaluated in these three aspects, the average score for the worksheets falls into the practical category. These worksheets can capture the interest of students, are easy for them to use, and have content that is relevant to the designated learning material and objectives (Frisilia & Hardeli, 2022; Fatmawati et al., 2023; Marlina & Wiyono, 2023). A set of worksheets is considered practical when suitable for learning (Hendrayani et al., 2022).

The Effectiveness of the Student Worksheet

Direct-instruction worksheets are evaluated based on problem-solving test scores and the achievement of learning goals in student worksheets or LKPD I, II, and III. The worksheets are considered effective when the learning objectives are achieved (Mukti et al., 2018). The attainment of KPM is assessed by evaluating students' responses to filling out the provided student worksheet and assessing their achievement at each meeting. The improvement in students' problem-solving skills or KPM can be observed in Figure 2.

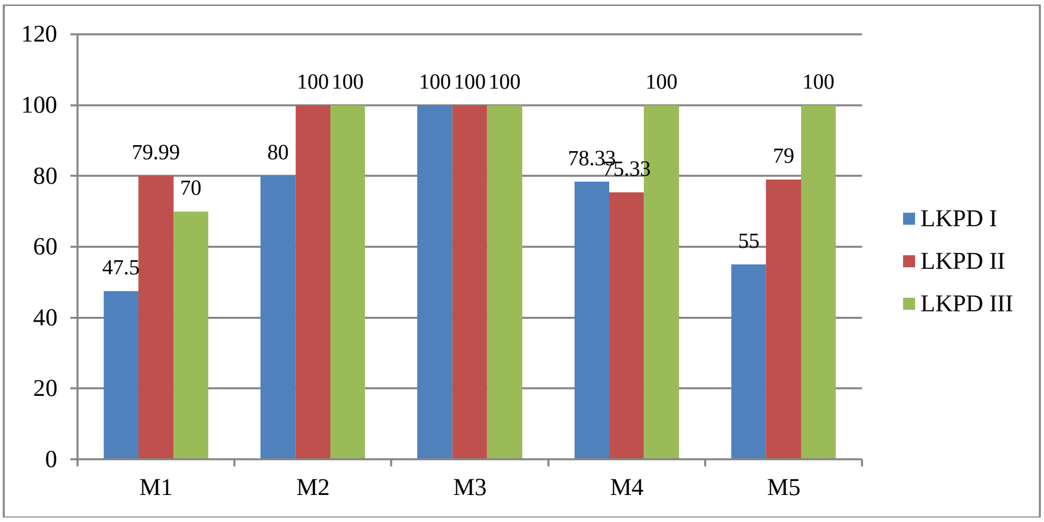

Figure 2 Increase in KPM's graph

Based on Figure 2, the achievement for each assessed indicator of learning objective mastery (KPM) is as follows: 1) visualizing or understanding the problem (M1); 2) describing the problem in terms of physics concepts (M2); 3) planning a solution (M3); 4) implementing the solution (M4); and 5) evaluating the solution (M5). The students' problem-solving skills, as evaluated in Worksheet I, had an average score of 72.16, categorized as 'good'. For Worksheet II, the average score was 87.06, falling into the 'very good' category, and for Worksheet III, the average score was 94.00, also categorized as 'very good'. This indicates an improvement in the student's problem-solving skills in each meeting. This is further supported by the analysis of problem-solving N-gain presented in Table 3.

Table 3 N-Gain problem-solving

Score		N-gain	
Pre-test	Post-test	<g>	Category
11.48	61.24	0.56	Average

Based on Table 3, the effectiveness measurement is conducted by comparing the pre-test and post-test scores. This is done to evaluate the extent to which the developed Direct-Instruction-Oriented Worksheets impact and lead to improvement in the students' problem-solving skills (Awaliyah, 2015). In the pre-test results, it was found that none of the students were able to reach the Minimum Completeness Criteria (KKM). This study considers students proficient if they meet the predetermined minimum completeness standard. The average score in the pre-test remains low, indicating that the student's problem-solving skills are still lacking and need improvement. Conversely, the post-test results show an improvement in the students' problem-solving skills, although they have not yet reached the desired level. This is supported by the N-Gain analysis (Table 3), which indicates a moderate improvement in problem-solving skills. Therefore, the developed Direct-Instruction-Oriented Worksheets can be considered effective, even though they have not yet reached the expected KKM.

CONCLUSION

Direct-instruction-oriented worksheets have met the validity, practicality, and effectiveness criteria, making them suitable for enhancing problem-solving skills in physics learning. A recommendation for future research is to conduct a broader-scale trial of these worksheets on different physics topics across various educational levels.

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