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Development of Student Worksheets on Dynamic Fluids Material to Improve Science Literacy

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Abstract
Science literacy is one of the skills and competencies needed in physics learning. However, literacy skills need to be well-practised and have received little attention from schools. This research aims to develop science literacy-based student worksheets that are valid, practical, and effective and, therefore, appropriate for improving students' science literacy. This development study uses the ADDIE development model, which includes analysis, design, development, implementation, and evaluation. The study used a one-group pre-test and post-test method with 35 students from class XI MIPA 4 at SMAN 8 Banjarmasin. Data collection instruments included validation, lesson plan observation sheets, and learning outcome tests. Data analysis techniques involved calculating the average score on validation and practicality results, which were then analyzed descriptively based on achievement categorization. The effectiveness analysis used the N-Gain formula. The research results indicate that (1) The student worksheets and learning outcome tests are valid with excellent criteria; (2) The student worksheets and learning outcome tests are practical with excellent implementation criteria; (3) The student worksheets and learning outcome tests are effective, as indicated by an N-Gain science literacy score of 0.58, categorized as moderate. Based on these results, the science literacy-based physics worksheets on dynamic fluids material that were developed are declared feasible and can be used in the learning process to improve students' science literacy. The developed worksheets offer an alternative for enhancing students' science literacy.
Keywords: fluid dynamics; scientific literacy; student worksheets

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INTRODUCTION

The rapid development of technology and information today makes science literacy a highly needed skill. Science literacy is not just about understanding scientific concepts but also the ability to apply them in daily life, especially in solving science-related problems (Dewantara et al., 2019; Lestari et al., 2021; Vieira & Tenreiro-Vieira, 2016). A society with good science literacy can think critically, analyze data, and make decisions based

on scientific knowledge, which is crucial in facing global challenges such as climate change, energy, and health. In education, science literacy must be instilled early on so that students can understand and apply scientific concepts optimally. One branch of science that requires deep understanding is physics, especially on complex topics like dynamic fluids. Given the low level of science literacy in various countries, including Indonesia, more effective learning approaches are needed to ensure that students not only understand the theory but can also apply it in solving everyday problems.

Science literacy is defined as the ability to understand scientific knowledge, identify problems, and draw conclusions based on evidence. It involves the skills to comprehend science and find opportunities to solve various issues. Additionally, science literacy includes students' scientific ability to identify problems, explain scientific phenomena, and draw conclusions based on relevant evidence (Odden et al., 2019; Pertiwi et al., 2018). Indicators help students identify questions and answer them through investigation, explain natural phenomena, identify variables, draw conclusions based on evidence, and use mathematics in science (Ardianto et al., 2019; Lusiana & Andari, 2022). Science literacy is essential for students as it helps them solve everyday problems. Every student should possess science literacy skills to understand and address various environmental and daily life issues (Hartini et al., 2019).

Initial observations at SMA Negeri 8 Banjarmasin involved questionnaires, tests, and interviews. Questionnaires were distributed to class XI MIPA 4 students through student worksheets to gauge their science literacy, and a pre-test was administered to measure their initial cognitive abilities. Upon reviewing the student worksheets responses, several problems were identified: (1) students' science literacy was poor, as they struggled to formulate problems, hypothesize, identify variables, analyze, and conclude accurately; (2) the pre-test results showed that out of 35 students, 15 could solve C2-type questions, 7 could solve C3-type questions, and no student could solve C4-type questions; (3) there was a lack of relevant learning resources to improve science literacy. The low science literacy in Indonesia is attributed to several factors, such as the education system, learning models, methods, learning resources, learning styles, and infrastructure used in learning (Odja & Payu, 2014; Pertiwi et al., 2018; Rahayu, 2017). Measuring science literacy is essential to assess the quality and capabilities of human resources. Through innovative learning that supports science literacy, students and educators are expected to enhance competitive performance (Nurcahyani et al., 2021).

Student Worksheets is one of the learning tools that guide students to perform tasks according to learning competencies and indicators to be achieved. The student worksheets also guides students in conducting investigations or problem-solving activities (Astutik & Prahani, 2018). The ADDIE development model (Analyze, Design, Development, Implementation, Evaluation) created this science literacy-based student worksheets. Through these student worksheets, students actively participate in learning, expressing ideas from their observations, and teachers benefit from the structured guidance provided by the student worksheets.

The use of the student worksheets to improve science literacy is supported by several previous studies: (1) Research by Ashari & Wisanti (2020) produced science literacy-based student worksheets to train students' critical thinking skills. These student worksheets foster analysis, interpretation, inference, explanation, and evaluation skills. Validation assessments showed that the student worksheets were

highly feasible in terms of construction, technical aspects, and didactics.; (2) Research by Prasetya et al., (2020) developed guided inquiry-based student worksheets that passed both validation and feasibility tests I and II with scores of 93.75% and 90.6%, respectively, indicating valid and excellent criteria. The use of these student worksheets proved effective in improving students' science literacy.; and (3) Research by Afsani et al. (2019) resulted in student worksheets suitable for enhancing students' science literacy. This study's novelty lies in the use of the student worksheets which has a significant impact on improving students' science literacy, not only focusing on dynamic fluid concepts but also addressing sustainability issues in the environment.

METHOD

This study is a development research (Research and Development). It aims to develop student worksheets to improve the science literacy of high school students (Sugiyono, 2019). The development model used is ADDIE, which includes (1) Analysis Stage, focusing on curriculum analysis, student characteristics, and student worksheets characteristics; (2) Design Stage, which involves characterizing the material and basic competencies; (3) Development Stage, where the student worksheets is created and validated; (4) Implementation Stage, involving student worksheets trials; and (5) Evaluation Stage, where the researchers evaluate the student worksheets based on the implementation of the lesson plan. The development involved validation by two lecturers from the Physics Education program at FKIP Universitas Lambung Mangkurat as academic experts, and one Physics teacher from SMAN 8 Banjarmasin as a practical expert. The test subjects were 35 students from class XI-MIA 4 at SMA Negeri 8 Banjarmasin. This study aimed to determine the feasibility of the student worksheets on dynamic fluids to improve students' science literacy, measured through validation, practicality, and effectiveness.

The research instruments were divided into three parts: 1) Validation of science literacy-based student worksheets using a validation sheet to measure the validity of the teaching materials, assessed by expert validators and practitioners; 2) Observation of the lesson plan implementation using an observation sheet to gather information about the practicality of the student worksheets; and 3) Student learning outcomes test used to evaluate the effectiveness of the student worksheets in improving science literacy. The criteria for validating the science literacy-based student worksheets are shown in Table 1.

Table 1 The student worksheets validity criteria

Average Score	Category
$\underline{x} > 3.4$	Very good
$2.8 < \underline{x} \leq 3.4$	Good
$2.2 < \underline{x} \leq 2.8$	Fair
$1.6 < \underline{x} \leq 2.2$	Poor
$\underline{x} \leq 1.6$	Very poor

(Widoyoko, 2016)

The effectiveness of the science literacy-based student worksheets can be analyzed using the pre-test and post-test results of science literacy. The science literacy framework used in this research includes (1) identifying questions answered through investigation, (2) explaining natural phenomena, (3) identifying variables, (4) drawing conclusions based on evidence, and (5) using mathematics in science. The science literacy test scores were calculated using the formula: the score obtained divided by the maximum score, multiplied by 100, and then categorized according to Table 2.

Table 2 Science literacy criteria

Score	Criteria
$66.6 < x \leq 100$	High

Score	Criteria
33.3 < x ≤ 66.6	Medium
0 < x ≤ 33.3	Low

The level of science literacy improvement was calculated using the normalized gain score. The N-gain value is categorized (Hake, 1999) as shown in Table 3.

Table 3 N-gain criteria (g)

N-gain (g)	Criteria
g > 0.7	High/Very Effective
0.3 ≥ g ≥ 0.7	Medium/Effective
g < 0.3	Low/Less Effective

The product of the Science Literacy student worksheet on the Dynamic Fluids material is shown in Figure 1.

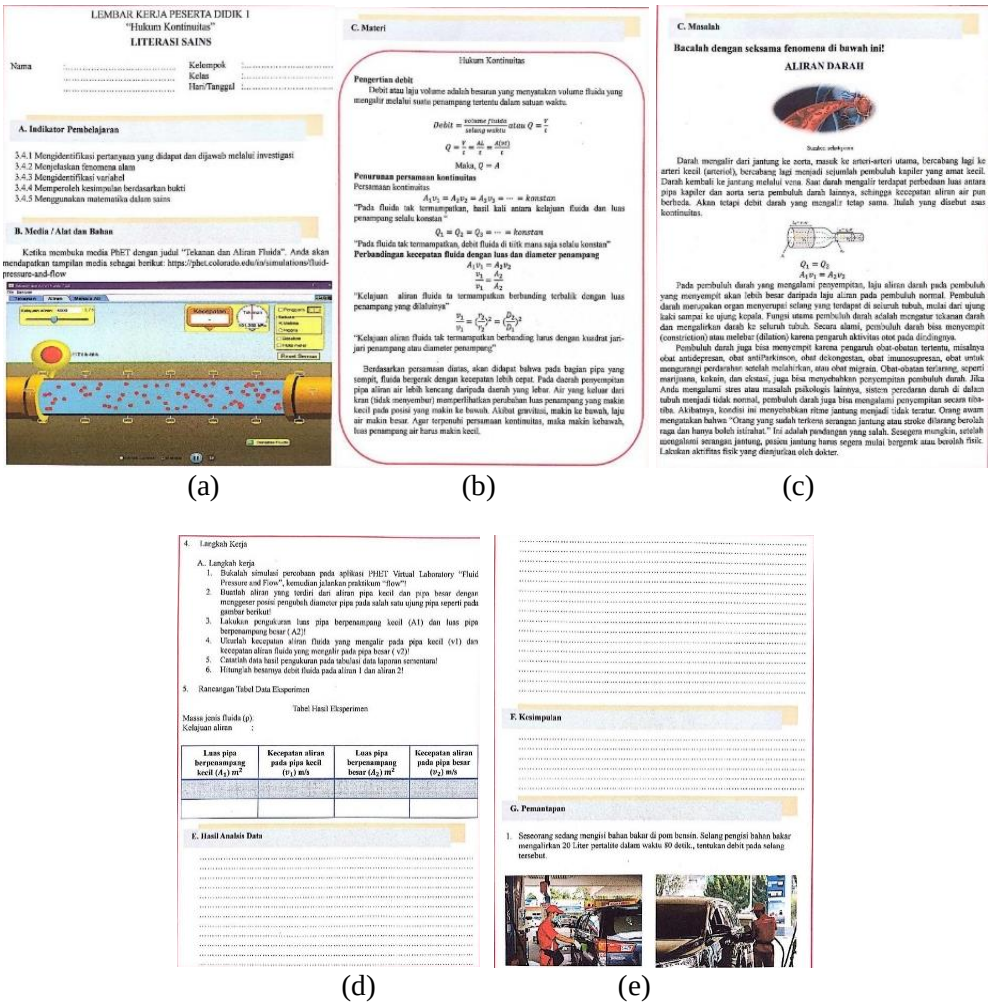

Figure 1 Science literacy dynamic fluids student worksheets, sections: (a) indicators and learning media, (b) material, (c) problems, (d) work steps, and (e) conclusions and consolidation

RESULTS AND DISCUSSION

The student worksheets was developed using a scientific approach, incorporating the PhET Simulation. In the initial section, the student worksheets includes a "Material" section to deepen students' understanding. Afterward, students observe a phenomenon related to blood

flow and are asked to identify questions that arise for experimentation. In the student worksheets (Figure 1b), students conduct experiments and fill in blank spaces on the worksheet. At the end of the student worksheets, a "Consolidation" section is included to improve students' analysis after conducting experiments. Through this student worksheets, students are encouraged to observe a phenomenon related to dynamic fluids, identify scientific questions arising from the phenomenon, and explore their thoughts by conducting classroom experiments. The student worksheets was designed based on science literacy competencies, according to OECD (2018).

The validation results of the student worksheets can be seen in Table 4.

Table 4 The student worksheets validation results

No	Assessment Aspect	Score	Category
1	format	2.9	Good
2	Language	3.0	Good
3	Content	3.1	Good
	Validity	3.1	Good

Based on the validation results, the student worksheets that was developed falls under the "Good" category, with an average score of 3.1. This meets the validation criteria, as the average score of 3.1 is classified as "Good." This aligns with Dwinanda Wahab et al., (2021) that this learning module facilitates teachers by helping students easily understand and master integrated science learning. It is also consistent with Lestari et al. (2021), who found that e-worksheets based on science literacy, validated using a science literacy validation sheet, were categorized as good and could be used for physics learning.

The student worksheets was effectively implemented based on observations of the lesson plan execution, with an average score of 3.66, which meets the "Very Good" criteria for use in learning. This is in line with Lailis et al., (2021) that RPP implementation can reflect a teacher's ability to apply phases of multi-model-based learning. Guided inquiry-based learning resulted in varied science literacy abilities among students, which improved after this learning approach was applied (Aulia et al., 2018). Using a scientific approach enhances students' science literacy (Andriani et al., 2018). Additionally, students' science literacy can be improved through Problem-Based Learning (PBL) (Prastika et al., 2019).

The results of the science literacy tests for class XI MIPA 4 students at SMAN 8 Banjarmasin, with 35 students, were obtained from pre-test and post-test scores using the developed learning tools to analyze effectiveness. Based on these test results, the scores were calculated concerning the five science literacy indicators, and N-Gain tests were used for analysis, as shown in Table 5.

Table 5 Scores for each science literacy indicator

Indicator	*Pre-test* Score	*Post-test* Score	*N Gain*	Criteria
1	5.45 (Low)	35.00 (Medium)		
2	49.15 (Medium)	91.55 (High)		
3	28.7 (Rendah)	48.15 (Medium)	0.58	Medium
4	54.45 (Medium)	75.55 (High)		
5	65.00(Medium)	100.00 (High)		

Description: 1) Identifying questions that can be investigated; 2) Explaining natural phenomena; 3) Identifying variables; 4) Drawing conclusions based on evidence; 5) Using mathematics in science

The effectiveness of the learning tools was assessed based on students' science literacy test results from the pre-test and post-test using the developed tools. Table 5 shows the analysis of science literacy based on several indicators, using the N-

Gain test. It displays the achievement and criteria for each science literacy indicator before (pre-test) and after (post-test) the learning process. The table shows students' initial abilities on each indicator were in the "Low" category. After learning with the developed tools, two indicators improved to the "Medium" category, while three indicators increased from "Medium" to "High." The students' science literacy results had an average N-Gain of 0.58. This data indicates that students' science literacy improved after learning the developed tools, although some remained in the "Low" category.

Considering the minimum competency threshold of 70, the average pre-test and post-test scores were still below the standard. The learning outcomes used to measure the effectiveness of the student worksheet development were the learning outcomes of students who attended every session. The N-Gain score of 0.58 demonstrates that their science literacy was in the "Medium" category.

The pre-test and post-test science literacy results are shown in Table 5. The test consisted of five questions, each covering one science literacy indicator students had to solve. Each question contained information that required students to apply two scientific process skills to solve the problem. Table 5 shows that students' pre-test results were low, mainly due to the lack of worksheets that trained science literacy and traditional teaching methods. Additionally, before implementing the science literacy-based LKPD, students were provided with worksheets and asked to answer consolidation questions from those worksheets.

After implementing the science literacy-based student worksheet 4.4, the overall N-Gain score was categorized as "Medium." The effectiveness of the student worksheet was demonstrated by the increase in students' learning outcomes before (pre-test) and after (post-test) using the developed student worksheet on dynamic fluid materials. This aligns with the findings of (Rahmita and Wasis, 2022), who stated that the guided inquiry-based student worksheet with PhET simulation effectively reduced students' misconceptions about dynamic fluids, significantly improving conceptual understanding. Similarly, Muzijah et al., (2020) found that the N-Gain learning test score of 0.41 was categorized as effective, showing that the e-module in the exe-learning application was suitable for training students' science literacy. This is also consistent with research by Aswita et al., (2022); Ummah et al., (2018), which found that the developed student worksheet met the needs and effectively improved students' science literacy. Students were able to connect their knowledge with real-life applications. The data collected showed good results, and the science literacy-based student worksheet developed was effective and practical, with a "Medium" N-Gain score.

The effectiveness of the student worksheet falls under the "moderate" category, meaning that overall, the developed student worksheet is quite effective in improving students' science literacy. The description above shows that the developed worksheet can be considered effective as it meets the intended goal of enhancing students' science literacy. This aligns with (Afiat, 2022) that local culture integrates science literacy. The N-Gain score is used to measure the improvement in science literacy before and after the learning process.

The dynamic fluids student worksheet was developed with the primary goal of enriching the science literacy of students in Indonesia. Science literacy is fundamental in education, encompassing the understanding, analysis, and ability to effectively communicate scientific concepts (Khasanah et al., 2021). This research focuses on using the student

worksheet as a learning tool in the domain of dynamic fluids, covering concepts such as the continuity principle, Bernoulli's law, and the applications of Bernoulli's law. This research emphasizes the need for a student-centred, active learning process. Therefore, the researchers carefully designed the student worksheet through several important stages.

The analysis conducted on the dynamic fluid material aimed to identify points that are often confusing for students, in order to formulate very specific and measurable learning objectives. These objectives should clearly define students' expectations by the end of the learning process using the student worksheet (Ariani & Yolanda, 2019; Hadiningrum et al., 2023). Moreover, the problem-based activities in the student worksheet consistently encourage students to think critically. In these activities, students face real-world problems and can formulate solutions by applying dynamic fluid science concepts (Juliarti, 2022; Ergul et al., 2011; Zaidah & Pransisca, 2020).

One such activity involves students using the student worksheet to experiment with Pressure and Fluid Flow using PhET simulations. During this activity, students are asked to identify research questions, explain natural phenomena, identify variables used in the research, draw conclusions, and apply equations to solve cases. These steps indirectly train students in science literacy, especially integrated science literacy.

The activities carried out while working on the student worksheet also emphasize student interaction and collaboration. Group discussions and joint exploration are important tools that facilitate a deeper understanding of scientific concepts (He et al., 2021; Jufrida et al., 2019). Students are encouraged not only to understand the concepts but also to communicate their knowledge confidently. As a result, students gain a better understanding of dynamic fluid scientific concepts and develop the ability to communicate their knowledge more confidently (Afnan et al., 2023). In an era where understanding science is crucial, developing student worksheet focused on science literacy can be an excellent step in supporting effective science education.

This study has some weaknesses, including the following: During the learning process, the teacher occasionally needs to check the students' focus to determine which students are paying attention to the explanations, demonstrations, or simulations related to the taught material. The science literacy test results show improvement but only within the "moderate" category, and some learning steps were not fully optimized, leading to each session lasting more than one hour, likely due to students' adjustment period.

CONCLUSION

Based on the results of product development and trials, it was concluded that (1) Student worksheets and learning outcome tests are valid with very good criteria; (2) Student worksheets and practical learning outcome tests with learning implementation criteria are very good; (3) Student worksheets and learning outcome tests are effective because the literacy N-gain score is 0.58 with moderate criteria. Thus, it can be concluded that the developed physics student worksheets based on scientific literacy on dynamic fluid material is feasible to be used in the learning process to improve students' scientific literacy. The developed student worksheets is one alternative to improve students' scientific literacy.

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