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Development of Student Worksheets on Dynamic Fluids Material to Enhance Scientific Creativity

Monica Maya Lusia, Suyidno*, Sarah Miriam, and Dewi Dewantara
Physics Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia
* suyidno_pfis@ulm.ac.id

Abstract

Scientific creativity involves creating innovative ideas, thoughts, or concepts. Scientific creativity in schools is not sufficiently trained. This study aims to produce valid, practical, and effective dynamic fluids student worksheets that are suitable for enhancing students' scientific creativity. This study applied the ADDIE model with 34 test subjects from the XI MIPA 3 class at SMA Negeri 8 Banjarmasin. Data were obtained from validation sheets, student response questionnaires, and learning outcome tests. The results showed that: (1) The student worksheets is considered valid because the validation results of the student worksheets and learning outcome tests were categorized as very good; (2) The student worksheets is considered practical because the results of the student response questionnaires were categorized as good; (3) The student worksheets is considered effective because the N-Gain of scientific creativity was 0.70, which falls into the high category. The developed dynamic fluids student worksheets is appropriate for enhancing students' scientific creativity in physics learning. Teachers can use this the student worksheets as an alternative to improve students' scientific creativity in physics education efforts.

Keywords: Dynamic fluid, scientific creativity, student worksheets.

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INTRODUCTION

Education is a means to improve a person's attitude, thinking, and behaviour to be more advanced than before receiving education. This education can be obtained in the family environment, school, and society (Abdurakhman & Rusli, 2015; Rahmat, 2019; Suprijanto, 2012). School education includes several subjects, one of which is science. Science is a way of understanding concepts closely related to nature. In learning science, students usually gain much experience, where they can develop a series of processes known as scientific processes, compared to the basic scientific attitude, and the results are realized in scientific products (Abdurakhman & Rusli, 2015; Herliani et al., 2021).

Scientific creativity, also known as creativity in the field of science, involves sensitivity to problems, the ability to create new ideas that are technically

acceptable, and the ability to ask questions, understand the surrounding environment, and solve problems (Fadhilah et al., 2022; Hussain et al., 2011). Students need to be able to determine the use of objects for scientific purposes, solve problems in science, enhance the technical usability of products, and design products creatively (Haryandi et al., 2021; Suyidno, Nur, et al., 2017; Suyidno et al., 2019a).

Based on initial observations at SMA Negeri 8 Banjarmasin, several issues were found: students needed to work on solving science problems, determining the use of objects for scientific purposes, designing products creatively, and enhancing the technical usability of products. This indicates that the scientific creativity possessed by the students is categorized as poor. Additionally, there are no relevant learning resources to train scientific creativity, as the learning resources used include physics textbooks in the library, mass media, and students' notes from teachers' explanations, which do not encompass students' scientific creativity.

Interviews with physics teachers revealed that the learning process still needs to achieve its objectives. Students are only accustomed to being given formulas and material notes without understanding where the formulas come from. This causes students to need help often answering the questions teachers give. Furthermore, teachers mentioned that they have never used learning media in the form of student worksheets, making using the student worksheets in physics learning, especially on dynamic fluids material, a new experience for students. One of the most needed learning resources is the student worksheets (Suryawati et al., 2020).

One effort to enhance students' scientific creativity is the development of the student worksheets based on scientific creativity. Students' creativity is positively and significantly related to their ability to solve physics problems, particularly in contextual learning (Rahmah et al., 2023; Suyidno, et al., 2017). Research results Hervyanti & Muchlis (2021) indicate that collaborative creativity-based the student worksheets are valid and effective. Research Wahyu & Madlazim (2018) shows that the developed student worksheets is 72% valid and very practical with 100% learning implementation.

The results of the above studies indicate that no the student worksheets specifically focused on scientific creativity for dynamic fluids material. Based on the above description, this research aims to produce a valid, practical, and effective the student worksheets on dynamic fluids material to enhance students' scientific creativity. The developed student worksheets is expected to maximize students' responsibility in enhancing scientific creativity.

METHOD

Research and development is the type of research applied. This research aims to produce a scientific creativity the student worksheets. This research and development aims to determine the validity, practicality, and effectiveness of the dynamic fluids the student worksheets to enhance scientific creativity. The development design in this study followed the ADDIE model (Analyze, Design, Development, Implementation, and Evaluation) (Tegeh et al., 2014). The stages were: (1) Analysis, which included curriculum analysis, teaching material analysis, and student characteristics analysis; (2) Design, which was the initial setup stage of the student worksheets; (3) Development, where the student worksheets was created in printed form and validated by two academic experts and one practitioner; (4) Implementation, which involved a small-scale trial of the

student worksheets; (5) Evaluation, which involved evaluating the student worksheets based on validation results by the researchers.

The research was conducted from February to July 2023 at SMA Negeri 8 Banjarmasin. The test subjects were scientific creativity trained using the physics student worksheets on Dynamic Fluids material. The research objects were 34 students from the XI MIPA 3 class at SMA Negeri 8 Banjarmasin for the even semester of the 2022/2023 academic year.

Data collection techniques in this research included: 1) Scientific creativity the student worksheets, validation sheets to measure the validity of the learning materials, 2) Student response questionnaires used to determine the practicality of the student worksheets, 3) Students' achievement tests to evaluate the effectiveness of the student worksheets.

The indicators of scientific creativity studied are solving scientific problems, determining the use of objects for scientific purposes, designing products creatively, and enhancing the technical usability of products. The data analysis technique uses the average value of the three validators, then the results are adjusted to the assessment criteria to analyze the level of validity of the scientific creativity student worksheet. The validity criteria for the student worksheets used can be seen in Table 1.

Table 1 Criteria for the student worksheets Validity and Practicality

Score Interval	Category
$\underline{x} > 3{,}2$	Very Good
$2{,}4 < \underline{x} \leq 3{,}2$	Good
$1{,}6 < \underline{x}\ 2{,}4$	Fair
$0{,}8 < \underline{x} \leq 1{,}6$	Good Enough
$\underline{x} \leq 0{,}8$	Poor

(Widoyoko, 2016)

The practicality criteria for the student worksheets are analyzed based on student response questionnaires, as shown in Table 1. The effectiveness level of the scientific creativity student worksheets can be analyzed using students' learning test results. The learning test can be considered effective if it meets the criteria in Table 2.

Table 2 Criteria for the student worksheets effectiveness

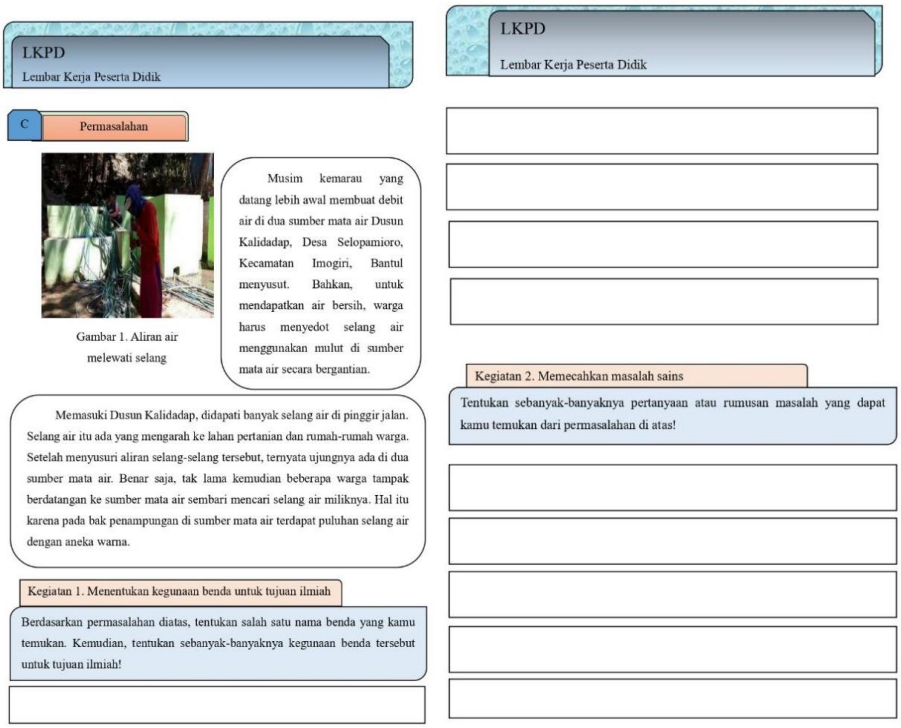
Average score	Category
$80 < X \leq 100$	Very Good
$65 < X \leq 80$	Good
$55 < X \leq 65$	Fair
$40 < X \leq 55$	Good Enough
$X \leq 40$	Poor

(Suyidno et al., 2020)

RESULTS AND DISCUSSION

The research and development produced a student worksheets on dynamic fluids material to enhance scientific creativity. Academics and practitioners then assessed the device for feasibility, covering the student worksheets validity, practicality based on student response questionnaires, and product effectiveness based on learning test results.

The student worksheets was developed through an everyday life approach, with problems presented through a narrative of someone watering plants using a hose, as seen in Figure 1 (a). Subsequently, students were directed to complete Activities 1 to 4 in the student worksheets. The goal of these activities is to develop students' scientific creativity. The first activity encourages them to think creatively about the use of everyday objects. The second activity focuses on solving scientific problems, while the third emphasizes the technical aspects of science. The fourth activity is the culmination stage, pushing students to design creative and practical products.



(a) (b)

(c)

Figure 1 Dynamic Fluids the student worksheets

During the development stage, two lecturers from the Physics Education program at FKIP Universitas Lambung Mangkurat acted as academic experts and one Physics teacher from SMAN 8 Banjarmasin as a practical expert. They reviewed components such as format, content feasibility, language,

presentation, and graphics. The student worksheets validation results are shown in Table 3.

Table 3 The student worksheets validation results

Aspect	Validity	
	Score	Category
Format	3.44	Very Good
Content Feasibility and Components	3.67	Very Good
Language and Components	3.50	Very Good
Presentation	3.56	Very Good
Graphics and Components	3.33	Very Good
Reliability	0.64	Good

Table 3 shows that the validity of the aspects of format, content feasibility and components, language and components, presentation, and graphics and components are categorized as very good, and reliability is good. This aligns with Rustaman's statement (Majid & Rochman, 2014), which suggests that a good the student worksheets should (1) contain all instructions needed by students; (2) be written in easy-to-understand language with short sentences and age-appropriate vocabulary; (3) include questions that students must answer; (4) provide space for students to write their answers and findings; (5) record the activities performed; and (6) use simple and clear illustrations. This is consistent with Prasojo's view (Hartini et al., 2018) that the student worksheets should include activities related to learning and questions.

The developed student worksheets consists of a cover, preface, table of contents, usage instructions, introduction, concept map, the student worksheets 1, the student worksheets 2, the student worksheets 3 covering scientific creativity indicators, consolidation questions, answer keys, author bio, and references. This matches (Aldila et al., 2017), stating that a good the student worksheets format includes titles, basic competencies, learning instructions, indicators, concepts, tools and materials, tasks and steps, assessment, the student worksheets content format, and supporting information. Furthermore, an attractive the student worksheets design can make students more enthusiastic about learning. This aligns with Laksana's statement (Mellenia & Admoko, 2022) that an attractive the student worksheets design can improve students' focus. According to Wulandari et al. (2021), the student worksheets design should not be limited to one form but can be developed by educators.

The practicality of the student worksheets was measured using a 20-item student response questionnaire. The results are shown in Table 4.

Table 4 Practicality response results of the student worksheets

Aspect	Score	Category
Ease of Use	2.64	Good
Usefulness	2.82	Good
Efficiency	2.57	Good
Average	2.68	Good

Table 4 shows the practicality of test results based on student responses regarding the developed student worksheets, assessed from ease of use, usefulness, and learning time efficiency. The practicality of the student worksheets scored an overall 2.68, categorized as good and thus considered practical. We can determine whether students are satisfied and understand the learning material based on student responses. This aligns with Andriani, Saparini, and Akhsan (Mahjatia et al., 2021) that student responses help gauge their opinions about the learning process.

The student worksheets was developed to enhance students' scientific creativity, so the content of the worksheets will be used to gather data on scientific creativity. Each meeting presented four activities. Activity 1 is designed to enhance the ability to determine the use of objects for scientific purposes; students are expected to identify one object from a given problem

and determine as many uses for that object as possible for scientific purposes (Nurcahyani et al., 2021). The student worksheets was developed to enhance students' scientific creativity, so the content of the worksheets will be used to gather data on scientific creativity. Each meeting presented four activities. Activity 1 is designed to enhance the ability to determine the use of objects for scientific purposes; students are expected to identify one object from a given problem and determine as many uses for that object as possible for scientific purposes (Azizah, 2022; Lestari & Gunawan, 2020). Activity 3 emphasizes students' ability to determine the technical usability of products. They are expected to identify improvements that can be applied to objects to make them easier and more practical, a vital step in developing creative thinking in the technical aspects of science (Lusiana & Andari, 2022; Rahma et al., 2020). Activity 4 is the culmination of these activities, where students are encouraged to design technically innovative and practical products. They will have the opportunity to plan products that are not only innovative but also practical to use. Additionally, students will be asked to identify the parts of the product and their functions, which will help sharpen their understanding of technical elements in science (Ariani & Yolanda, 2019).

In this learning process, the role of the student worksheets becomes very important, as the student worksheets allows students to undergo a more in-depth and structured learning experience. Through this process, students acquire theoretical knowledge and are expected to apply the concepts and skills they have previously learned in a practical context. One of the goals pursued is for them to be able to produce products that are not only creative but also incorporate the scientific elements they have studied (Astutik & Prahani, 2018; Lusiana & Andari, 2022).

The student worksheets provides a structured framework to guide students in exploring various aspects of scientific creativity. Additionally, the student worksheets plays a role in creating an environment that encourages collaboration and group work. In this learning setup, students collectively seek answers to complex problems. They will discuss, share ideas, and design solutions together (Hadiningrum et al., 2023). This process allows students to utilize each group member's diverse perspectives and skills (Respita, 2020). Students not only seek solutions individually but also collaboratively. This reflects how science is often developed in teamwork and involves solving complex problems (Suyidno et al., 2019b). Through this cooperation, they can maximize their creativity and scientific potential.

The practicality of the learning tools can be measured through two criteria: 1) their actual application in the field and 2) expert assessment of their implementation. A tool is considered practical if it can be applied in the field and its implementation is categorized as good (Mustaming et al., 2015).

The effectiveness of this study is reviewed from the results of the students' achievement tests. The achievement tests is used to measure the effectiveness of the the student worksheets in the learning process. This aligns with (Suhardiman et al., 2022), who state that the achievement tests can be used as a benchmark for learning effectiveness. The effectiveness test evaluates the product's effectiveness in learning (Kurniawiguna et al., 2015). The achievement tests is administered before and after the material is taught. These results are then used to calculate N-Gain, as shown in Table 5.

Table 5 *N-Gain* Results

Average of pre-test	Average of post-test	N-Gain	Category
25.21	77.70	0.70	High

Table 5 shows that the N-Gain value is 0.70, which is categorized as high. This indicates that the developed student worksheets is effective for learning.

In line with Effendy (2016), the pre-test and post-test results are used as feedback to enhance students' interest. The pre-test and post-test serve as tools to assess the effectiveness of learning. The pre-test results are compared with the post-test results to evaluate the understanding and success of the learning process. It is hoped that students will become more interested and enthusiastic about the lessons, thus improving their learning outcomes. This is consistent with the study (Suparinda & Wasis, 2022), which shows that post-test results improved compared to pre-test results. According to Ayuwati (Purnamasari et al., 2018), the increase in students' learning outcomes results from an output from a system that processes input in the form of information and outputs in the form of students' work or actions.

During this research, the developed student worksheets will provide a deeper understanding of students' scientific creativity development. The data collected from these worksheets will serve as a basis for continuous evaluation and updates. Using the student worksheets as a tool to develop students' scientific creativity enriches their learning experience and enables teachers to design more effective approaches to enhance their scientific creativity (Juliarti, 2022; Zaidah & Pransisca, 2020). Thus, the student worksheets becomes not just an ordinary learning tool but an instrument that supports exploring scientific creativity in learning.

One weakness of this research is that lesson scheduling needs to be optimized further. This is because lesson times and breaks are reduced during the fasting month, causing students to arrive late to class often. During the lessons, the teacher must occasionally check students' focus to identify those genuinely paying attention. Sometimes, some students do not fully engage with the tasks and rely solely on their group mates.

CONCLUSION

The conclusions of this research are: 1. The developed student worksheets is valid, as the validation results for general construction, language, and test instrument content are categorized as good or valid. The validation results for the scientific creativity test are also categorized as very good or very valid. 2. The developed student worksheets is practical, as the students' responses in each aspect are categorized as practical. 3. The developed student worksheets is effective; the N-Gain score for scientific creativity is 0.70, categorized as high. This research has shown a tangible implication in the form of increased scientific creativity among students. Thus, the developed product can be used by teachers as it supports students' creativity by providing a learning process that trains their creativity.

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