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The Effect of Digital Worksheets on Dynamic Fluids with Authentic Learning in Training Problem-Solving Skills

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Abstract

Considering the importance of problem-solving skills in the 21st century, students should be trained in these skills, especially in sciences such as physics. Therefore, teaching materials such as worksheets are needed to train these skills. This study aims to describe the effect of digital worksheets on dynamic fluids with authentic learning in training students' problem-solving skills. The type of research used is pre-experimental with a one-group pretest-posttest design, with research subjects consisting of students in one of the XI MIPA classes in Barito Kuala Regency. The research data was collected through problem-solving skill tests before and after using the digital worksheets with the same material and then analyzed using normalized N-gain or gain scores. The results showed that the effect of the digital worksheets was in the high category with an N-gain score of 0.75, and students reached a good category in problem-solving skills. Therefore, it can be concluded that the digital worksheets on dynamic fluids with authentic learning effectively train students' problem-solving skills and can be used as input for teachers to train students' problem-solving skills.

Keywords: authentic-learning; digital worksheets; dynamic fluids; problem-solving skills

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INTRODUCTION

Education plays a crucial role in determining the progress of a nation. A developed nation has quality human resources, both spiritually, intellectually, and in skills. Good quality human resources enable a nation to be proactive in facing changes. Continuous renewal in education, especially physics, is important to achieve these goals.

Physics learning requires learning activities that provide opportunities for students to discover and apply the knowledge they acquire (Bakri et al., 2020). Physics is a part of science that studies the properties and phenomena of nature and their interactions (Aripin et al., 2021; Astuti et al., 2020; Ramadayanty et al., 2021; Ramadhani et al., 2021). Fundamentally, science forms the basis for the rapid technological advancements in the 21st century. This progress demands individuals to have a range of skills that meet 21st-century demands, including problem-solving

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skills (Aripin et al., 2021; Ayudha & Setyarsih, 2021).

Problem-solving skills are the ability to understand and solve problems through cognitive processing (Akben, 2020; Araiza-Alba et al., 2021; Lin et al., 2018; Patimah et al., 2022; Veerasamy et al., 2018). According to Winkler et al. (2021), problem-solving skills impact students' learning process, with those in experimental groups experiencing higher problem-solving skill levels. These skills are essential in physics learning because problems in physics learning are related to everyday life contexts (Ayudha & Setyarsih, 2021; Ramadayanty et al., 2021; Supriyadi et al., 2022; Yuberti et al., 2021).

The quality of students' answers to science problem-solving questions reflects their physics abilities. PISA 2018 ranked Indonesian students 71st out of 79 countries, showing low problem-solving skills in physics (Hewi & Shaleh, 2020; Khairunnisa & Ramlah, 2021).

Observations on one of the XII MIPA classes in Barito Kuala Regency showed low problem-solving skills among students. Tests assessing understanding of dynamic fluids using Polya and Heller steps showed that most students could only answer C3 level questions, needed help planning solutions, and struggled with C4 and C5 level questions. The main inhibiting factors were limited skills, lack of practice, and low motivation. Only 5.88% of students reached a fairly good category, 64.71% were in the less good category, and 29.41% were in the very poor category. Moreover, physics teachers still needed to implement problem-solving steps, and no teaching materials trained these skills. Therefore, a proper learning approach is needed to train these skills.

One solution is to use digital worksheets with authentic learning content. Digital worksheets are student worksheets completed digitally and continuously over a certain period (Fuadi et al., 2021; Wijayanti & Ernawati, 2020). Worksheets are tools used to assist and facilitate learning activities, imparting knowledge, attitudes, and skills to students. Worksheets can optimize teaching, guide students who have difficulties, give reinforcement, and train problem-solving skills (Budi et al., 2021; Lestari et al., 2021; Yanti et al., 2019). Digital worksheets were chosen based on student responses that supported its use. The advantages of digital worksheets include being practical, low risk, and easily accessible via mobile phones and the internet.

Research on digital worksheets has been widely conducted by previous researchers, such as Hidayati et al. (2022), who used digital worksheets based on PBL and Google Classroom for reaction rate material with critical thinking indicators, and Sari & Susilowibowo (2022), who utilized the Website Live Worksheet in digital worksheets to facilitate students in their discovery and knowledge.

Authentic learning allows students to explore and delve into problems in relevant real-world contexts (Gurjar, 2020; Herrington et al., 2010). In this approach, students learn through engagement in tasks to solve a problem. Authentic learning experiences involve real-world topics or issues and often provide opportunities for students to communicate, collaborate, and reflect (Lowell & Moore, 2020). Authentic learning offers flexible and relevant education, develops social analysis skills, and allows learning experiences related to the surrounding environment. However, its drawback is the longer learning time (Ramadhani et al., 2021; Singer, 2020).

Previous research has successfully used authentic learning. For example, Ramadhani et al. (2021) developed teaching materials on optical instruments relevant to real life, facilitating students'

understanding of abstract physics material. Additionally, Saputri et al. (2021) found that digital teaching materials based on authentic learning helped students easily understand and were highly preferred by students when accompanied by images.

Several previous studies have shown that digital worksheets with an authentic learning approach are effective in training students' problem-solving skills. The digital worksheets used in this study are unique as they are presented in PDF format, which can be downloaded via QR Code or bit.ly link. This allows students to access them without continuously connecting to the internet, thus saving internet data usage.

Physics material commonly encountered in daily life applications is moving (dynamic) fluids. This material is highly relevant in everyday life and technology (Malik et al., 2019; Saparini et al., 2020). The fundamental ability to apply fluid dynamics principles in technology greatly supports authentic learning in digital worksheets.

Based on the above analysis and observations, this study aims to describe the effect of digital worksheets on dynamic fluids with authentic learning in training students' problem-solving skills.

The uniqueness of these worksheets lies in integrating the Authentic Learning approach, which creates tasks relevant to real-world situations and provides a dynamic context to encourage adaptive thinking. This approach emphasizes the use of technology, supports collaboration and interactivity, and includes learning outcome tests at each meeting. This uniqueness is expected to enhance learning by focusing on developing students' problem-solving skills.

This research is important as it provides insights into the effect of digital worksheets on dynamic fluids with authentic learning in training students' problem-solving skills. The results of this study are expected to contribute to a better understanding of effective learning design, with the potential to influence educational practice and open new options for educators to create more relevant learning experiences.

METHOD

This type of research is pre-experimental, using a Group Pretest-Posttest design. The study was conducted in one XI MIPA class during the even semester of the 2022/2023 academic year in Barito Kuala Regency from December 2022 to April 2023. Figure 1 is the schema of the One Group Pretest-Posttest design.

Figure 1 Schema of One Group Pretest-Posttest (Sugiyono, 2019).

O1 is the score before treatment (pretest), X is the physics learning using digital worksheets on dynamic fluids with authentic learning (treatment), and O2 is the score after treatment (post-test). The effectiveness assessment uses pretest and post-test scores, first tested for normality using the SPSS 21 application. If the normality test results show significance above 0.05, the data is said to be normally distributed, and the N-Gain value can be calculated. The effectiveness criteria for worksheets are considered effective if the N-gain achievement level is at least in the medium category (Mahtari et al., 2020). The N-gain criteria in Table 1.

Table 1 N-gain value criteria

N-Gain Value	**Criteria**
$\langle g \rangle \geq 0.7$	High (Very Effective)
$0.7 > \langle g \rangle \geq 0.3$	Medium (Effective)
$\langle g \rangle < 0.3$	Low (Less Effective)

Adapted from Hake (1998)

Students' Problem-Solving Skills are measured based on problem-solving steps and categorized according to Table 2.

Table 2 Problem-solving skills criteria

Scores	Criteria
> 80	Very Good
> 60 – 80	Good
> 40 – 60	Fairly Good
> 20 – 40	Poor
≤ 20	Very Poor

Adapted from Arsyad et al. (2022)

RESULTS AND DISCUSSION

Academic and practitioner validators validated the digital worksheets used in the research before they were tested in class. The digital worksheets on dynamic fluids with authentic learning are packaged in a QR Code and bit.ly link, which are then used to support the learning process tailored to the characteristics of dynamic fluid material and the characteristics of XI MIPA students in the even semester of the 2022/2023 academic year.

According to Arifuddin et al. (2019), digital worksheets are interactive tools that enhance students' scientific creativity, help creative thinking, develop concepts, and apply them in daily life. The worksheets in this study were created using Microsoft Word 2013 and converted to PDF format, with the design done using Microsoft PowerPoint 2013. This worksheet can be accessed via mobile phones, making it easily portable. The worksheets with authentic learning content are fully presented in a QR Code, as shown in Figure 2.

Figure 2 Digital worksheets on dynamic fluids with authentic learning.

The digital worksheets with authentic learning feature an image of the floating market in South Kalimantan and problem-solving skills logo in the top right corner of the cover. This cover signifies the presence of problem-solving steps to train students in problem-solving at each meeting. The cover design can be seen in Figure 3.

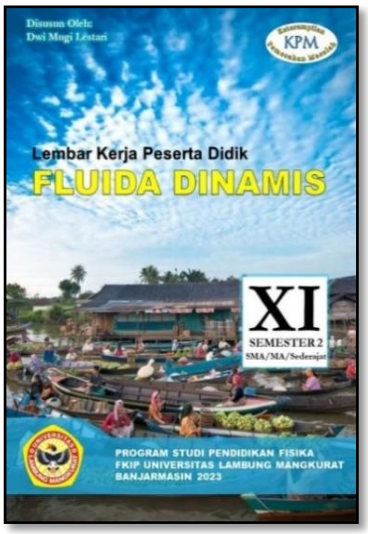

Figure 3 Cover display of worksheets

Authentic learning is presented in the problem orientation (Figure 4) and in each question within it (Figure 5) of these digital worksheets.

Figure 4 Problem orientation display with authentic learning content

The advantages of these digital worksheets lie in the practice questions with authentic learning content and the answer sheets that include four problem-solving steps: 1) understanding the problem, 2) planning the solution, 3) executing the solution, and 4) evaluating.

Figure 5 Question display in worksheets

The feasibility of a product can be determined by several criteria, one of which is effectiveness. Effectiveness is the success or achievement of a goal. While efficiency is used to measure the process, effectiveness measures the success in achieving the goal (Laksmi et al., 2023; Lin et al., 2018; Ma'mun, 2019).

The effectiveness of a product can be seen from student appreciation and learning outcomes measured through tests (Lase & Zai, 2022; Mahtari et al., 2020). The effectiveness of the digital worksheets is measured through students' learning outcome tests by comparing the average pretest and post-test scores, thus evaluating the effectiveness of the digital worksheets in training problem-solving skills (Aini et al., 2018; Mahtari et al., 2020; Wulantri et al., 2019; Yanti et al., 2019). Effectiveness analysis is conducted by providing six cognitive test items before and after the learning process. The pretest and post-test data are checked for normality with a significance >0.05, indicating a normal distribution (see Table 3).

Table 3 Normality test results

Data	Significance	Description
Pretest	0.937	Data distributed normally
Post-test	0.871	Data distributed normally

The learning outcome test is then calculated using normalized N-gain to determine the effectiveness of digital worksheets (see Table 4).

Table 4 Effectiveness results of digital worksheets

Pretest Average	Post-test Average	<g>	Category
3.82	75.88	0.75	High

Based on the data in Table 4, the effectiveness of the digital worksheets is categorized as high, with an N-gain score of 0.75. These results indicate that the digital worksheets on dynamic fluids with authentic learning can be considered effective for application in learning, as there is a significant increase in students' cognitive abilities.

Initially, students had low pretest scores because they were not accustomed to the problem-solving steps in physics. After using the digital worksheets with authentic learning, students found it easier to understand concepts through questions relevant to their daily lives (Ornellas et al., 2018; Sulistiani, 2018). The answer sheets aligned with the problem-solving steps and helped them practice their problem-solving skills.

According to Polya and Heller, the problem-solving skills indicators used adapt indicators, including understanding the problem, planning the solution, executing the solution, and evaluating. Therefore, the student's problem-solving skills score results from the learning

outcome test score multiplied by the weight that adjusts to the problem-solving skills indicators used.

All learning outcome test questions for the pretest and post-test consist of six essay questions with cognitive levels C3 to C5. Table 5 shows the students' problem-solving skills achievement.

Table 5 Analysis results of problem-solving skills

Aspect	Average Score	
	Pretest	Post-test
Understanding the problem	6	80
Planning the solution	3	72
Executing the solution	2	51
Conducting the evaluation	0	45
Average	2.6	62
Average Category	Very Poor	Good

Table 5 shows the achievement results of students' problem-solving skills before (pretest) and after (post-test) using the digital worksheets. Overall, the pretest category was very poor. One reason for this is the lack of teaching materials that train these skills and the lack of use of problem-solving steps in physics learning. During the pretest, students could only answer question number 1 with a cognitive level of C3, but they still needed to reach the evaluation step.

Students' problem-solving skills in the post-test average score showed variations in each aspect (see Table 5). Based on the problem-solving skills criteria (see Table 2), understanding the problem and planning the solution were categorized as good. However, the aspects of executing the solution and conducting the evaluation were categorized as fair. Most students needed help executing solutions for C4 and C5 level questions, so they could not fully evaluate their answers. This affected the average scores of these two aspects, which only reached the fair category.

Students found it difficult to work on C4 and C5 level questions due to the complexity of the problem-solving steps and the number of variables to consider. They tended to rely on memorizing formulas and could only reach the planning solution stage. To train problem-solving skills more effectively, it is advisable to provide simpler questions first. If students still need to become familiar with these skills, it is recommended that tutorial videos be included in the digital worksheets that explain how to solve C4- and C5-level questions. This will help students understand and get used to solving such problems.

Overall, the average score of students' problem-solving skills was categorized as good, with scores reaching above 60. This result shows an improvement from initially being far below 20 (very poor) to above 60 (good). This improvement is largely due to the authentic learning in the digital worksheets, which were intensively taught to students. Research (Ornellas et al., 2018; Supriyadi et al., 2022) supports this, stating that authentic learning enhances student learning outcomes. Through authentic learning, students can connect concepts in the material with real-life phenomena (Hussein, 2020; Ornellas et al., 2018).

The researchers provided step-by-step examples of problem-solving, and the students followed along and asked questions if there was something they needed help understanding. They were also given additional practice questions to work on independently at home. This method follows Albert Bandura's modelling theory, where the researcher acts as a model, providing examples to be observed and imitated, serving as a stimulus for the observer's (students') responses (Connolly, 2017). Students with weaker problem-solving skills are

well-suited for this learning method to help them become familiar with and trained in problem-solving steps.

CONCLUSION

This research shows that the Authentic Learning approach in the digital worksheets on dynamic fluids successfully improved students' problem-solving skills. Despite initially having low skills, students could understand, plan, execute solutions, and conduct evaluations after using the digital worksheets. Future research suggestions include strengthening tutorial video integration, expanding real-world projects, evaluating the long-term impact of digital worksheets, and exploring additional technologies to enrich learning. Hopefully, This will further enhance learning and improve students' problem-solving skills.

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