**Lensa: Jurnal Kependidikan Fisika**
Penerbit: Universitas Pendidikan Mandalika
https://e-journal.undikma.ac.id/index.php/Lensa/index

Dec. 2025, Vol. 13, No. 2
e-ISSN: 2686-0937
pp. 376-384

# The Implementation of Student Worksheets based on Project-Based Learning (PjBL) Model on Dynamic Fluid Material

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**Abstract**

The background of this study stems from the unavailability of Project-Based Learning (PjBL) model-based Student Worksheets (LKPD) used in high school physics instruction. The objective of this research was to develop a PjBL-based LKPD for the Dynamic Fluids topic at SMA Negeri 14 Medan. This study employed a Research and Development (R&D) approach using the ADDIE development model. The research subjects included material experts, media experts, learning experts, and 36 students from class XI-1 of SMA Negeri 14 Medan. The instruments used consisted of validation questionnaires completed by experts, observation sheets, interviews, and pretest-posttest assessments. The findings revealed that the developed LKPD met the criteria of validity, with validation scores of 78% from material experts, 75% from media experts, and 79.1% from learning experts. In terms of practicality, the LKPD was rated very practical, with student assessments scoring 92.3% and teacher assessments scoring 90.2%. The effectiveness test, measured using normalized gain (N-gain), yielded a score of 0.77, categorized as high. Thus, it can be concluded that the Project-Based Learning (PjBL)-based LKPD developed in this study is valid, highly practical, and effective for use in physics education.

**Keywords**: Project-based learning; Student worksheet; Dynamic fluids; Physics education; Instructional development

**How to cite**: Pandiangan, J. A., & Hakim , A. (2025). The Implementation of Student Worksheets based on Project-Based Learning (PjBL) Model on Dynamic Fluid Material. *Lensa: Jurnal Kependidikan Fisika*, *13*(2), 376–384. https://doi.org/10.33394/j-lkf.v13i2.17833

## INTRODUCTION

Twenty-first-century education emphasizes the importance of equipping students with essential competencies often referred to as the 4Cs: critical thinking, collaboration, communication, and creativity. These skills are crucial for addressing the demands of a globalized society and rapidly evolving scientific and technological landscapes. In this context, teachers play a strategic role in facilitating innovative learning experiences through the development of creative, contextual, and student-centered instructional tools that promote independent learning (Khalifah et al., 2021). The Indonesian government's response to these demands is reflected in the implementation of the Kurikulum Merdeka (Independent Curriculum), which emphasizes project-based learning and the strengthening of students' character development through the Profil Pelajar Pancasila framework (Oktaviara, 2023; Fitra, 2023).

Despite these policy initiatives, the quality of science education in Indonesia remains a concern. The 2023 Programme for International Student Assessment (PISA) results indicated that Indonesia ranked 68th out of 81 participating countries, with a science score of 398 and a reading score of 371, both showing a decline compared to previous assessments (OECD, 2023). Similarly, the Trends in International Mathematics and Science Study (TIMSS) 2015 report also highlighted

the low levels of scientific and mathematical literacy among Indonesian students (Hamzah, 2023). These findings suggest that Indonesian students still struggle to apply fundamental scientific concepts in real-world contexts, including core topics in physics such as dynamic fluids.

In response to these challenges, Project-Based Learning (PjBL) has emerged as a promising pedagogical model that fosters critical thinking, problem-solving abilities, and scientific conceptual understanding through meaningful and contextual project activities (Novianti, 2021). International research further supports the effectiveness of PjBL in enhancing student academic performance and creativity, particularly in science education (Bell, 2010; Han et al., 2021; Lou & Chou, 2022). Within this framework, Student Worksheets (Lembar Kerja Peserta Didik or LKPD) serve as essential instructional tools that guide students through active learning processes such as inquiry-based investigations, experimentation, and scientific discussions (Sudiar et al., 2023; Ramadhani, 2024). Well-designed LKPDs aligned with the PjBL approach can help bridge the gap between theoretical knowledge and practical application.

However, preliminary observations conducted at SMA Negeri 14 Medan revealed that physics instruction remains predominantly lecture-based, with limited use of LKPDs or hands-on laboratory activities. This teacher-centered approach has led to reduced student engagement, lower learning motivation, and unsatisfactory cognitive achievement. Consequently, there is a pressing need to develop alternative teaching materials that incorporate PjBL principles, specifically tailored to the topic of dynamic fluids—a subfield in physics that remains underrepresented in existing LKPD developments. Previous studies have primarily focused on developing PjBL-based LKPDs for other topics such as electric circuits, temperature, or waves, while systematic efforts to create such materials for dynamic fluid topics at the senior high school level remain scarce. Therefore, the present study introduces a novel contribution by focusing on a unique subject area, offering an original instructional product, and applying a structured development process.

This study aims to develop a Project-Based Learning-based Student Worksheet (LKPD) for the topic of dynamic fluids and to evaluate its validity, practicality, and effectiveness in enhancing the physics learning outcomes of grade XI students at SMA Negeri 14 Medan. It is anticipated that the developed LKPD will improve students' interest in physics, deepen their understanding of core scientific concepts, and strengthen their scientific thinking skills. Moreover, the outcomes of this research are expected to provide an innovative instructional alternative for teachers and serve as a scholarly reference in the development of project-based teaching media within the field of physics education.

## METHOD

This study employed a Research and Development (R&D) approach. Research and Development is a research method used to develop, validate, and produce educational products (Sugiyono, 2013). The development model applied in this study was the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

The stages and main activities of the ADDIE development model used in this research are presented in Table 1.

**Table 1.** ADDIE development model framework

| Stage | Main Activities |
|---|---|
| Analysis | - Analysis of problems and learning needs through teacher interviews.<br>- Analysis of student characteristics through questionnaires distributed to 36 students. |
| Design | - Preparation of identity, learning outcomes (CP), learning objectives (TP), and selected material indicators.<br>- Designing the structure of the Project Based Learning (PjBL)-based LKPD.<br>- Determining the systematic presentation of instructions, materials, activity sheets, conclusions, and references. |
| Development | - Development of the LKPD.<br>- Preparation of validation instruments for material experts, media experts, and learning experts.<br>- Validation by material, media, and learning experts. |
| Implementation | - Pretest to measure students' initial abilities.<br>- LKPD trial implementation.<br>- Posttest to measure improvement in learning outcomes. |
| Evaluation | - Evaluation of the LKPD based on expert validity (material, media, and learning), practicality, and effectiveness. |

The subjects of this study included material experts, media experts, learning experts, and students of class XI-1 at SMA Negeri 14 Medan. The research instruments consisted of validation questionnaires for lecturers and teachers, practicality questionnaires for teachers and students, and multiple-choice tests in the form of pretests and posttests to assess the effectiveness of the developed LKPD.

The collected data were analyzed using descriptive quantitative analysis, including the calculation of validity and practicality percentages, as well as normalized gain (N-gain) to determine improvements in students' learning outcomes.

Validity is defined as the extent to which an instrument measures what it is intended to measure. The validation process was conducted by material experts, media experts, and learning experts to evaluate the feasibility of the developed product. A four-point Likert scale was used in the validation sheets, consisting of: Very Good (VG), Good (G), Poor (P), and Very Poor (VP), as shown in Table 2 (Riduwan, 2010).

**Table 2.** Validation instrument categories using a likert scale

| Symbol | Response | Score |
|---|---|---|
| VG | Very Good | 4 |
| G | Good | 3 |
| P | Poor | 2 |
| VP | Very Poor | 1 |

The validation percentage was calculated using the following formula:

$$NA = \frac{S}{SM} \times 100\%$$

where:
NA = final score given by the validator
S = score obtained
SM = maximum possible score

The criteria for interpreting expert validation results are presented in Table 3.

**Table 3.** Criteria for validation interpretation

| Percentage (%) | Criteria |
|---|---|
| 0 – 20 | Not Valid |
| 21 – 40 | Less Valid |
| 41 – 60 | Fairly Valid |
| 61 – 80 | Valid |
| 81 – 100 | Very Valid |

Practicality data were obtained from practicality questionnaires completed by teachers and students. Each item was scored, summed, and converted into a final percentage score using the following formula:

$$NA = \frac{S}{SM} \times 100\%$$

where:
NA = final score
S = score obtained
SM = maximum score

The criteria for interpreting practicality levels are shown in Table 4.

**Table 4.** Practicality interpretation criteria

| Percentage (%) | Criteria |
|---|---|
| 0 – 20 | Not Practical |
| 21 – 40 | Less Practical |
| 41 – 60 | Fairly Practical |
| 61 – 80 | Practical |
| 81 – 100 | Very Practical |

The effectiveness of the PjBL-based LKPD was analyzed using pretest and posttest results, calculated through normalized gain (N-gain) analysis. Normalized gain measures the improvement in students' conceptual understanding after the learning intervention. The normalized gain formula used in this study is as follows:

$$Gain = \frac{Posttest\ score - Pretest\ score}{Max\ score - Pretest\ score}$$

The classification of normalized gain values is presented in Table 5.

**Table 5.** Normalized gain classification

| Average Gain Value | Category |
|---|---|
| -1.00 < g < 0.00 | Decreasing |
| g = 0.00 | No Change |
| 0.00 < g < 0.30 | Low |
| 0.30 < g < 0.70 | Medium |
| 0.70 < g < 1.00 | High |

The blueprint of the student test instruments used to measure learning outcomes is presented in Table 6.

**Table 6.** Student test instrument blueprint

| Material | Indicator | Number of Items |
|---|---|---|
| Dynamic Fluids (Continuity Equation, Bernoulli's Equation) | C1, C2, C3 | 1, 2, 2 |
| Application of Continuity and Bernoulli's Equations | C4, C5, C6 | 2,2,1 |

## RESULTS AND DISCUSSION

This study successfully produced a Student Worksheet (LKPD) based on the Project-Based Learning (PjBL) model for the topic of dynamic fluids. The developed LKPD fulfilled the criteria of being valid, practical, and effective. Its development followed the ADDIE instructional design model, which comprises five main stages. The implementation of each stage is described as follows:

### Analysis Stage

The analysis stage was conducted to examine the learning issues found at the school. It was discovered that learning resources were limited to printed textbooks, and no LKPD based on the Project-Based Learning (PjBL) model had been used. Within the *Kurikulum Merdeka*, the term LKS is replaced with LKPD. The use of conventional LKPDs led to minimal student engagement in practical activities or experiments, which are essential to increase student involvement in learning. Traditional lecture-based instruction dominated the classroom without engaging students directly, resulting in low motivation and a lack of variation, which often caused boredom among learners.

### Design Stage

The design stage aimed to construct a PjBL-based LKPD specifically for dynamic fluid material to support students' comprehension and learning outcomes. The design process consisted of several key steps:

a) Determining the identity section, including the educational level (Senior High School), curriculum (*Kurikulum Merdeka*), subject (Physics), class/semester (Grade XI/First Semester), and time allocation (2 × 45 minutes). The learning outcomes and objectives were aligned with indicators of dynamic fluid material.
b) Selecting the content, where the dynamic fluids topic was chosen and structured systematically based on the reference: *Giancoli, D.C. (2001). Physics, Fifth Edition. Jakarta: Erlangga*.
c) Designing the layout and structure, which was adapted to fit the PjBL model. The activity sheets were divided according to the syntax of PjBL: Driving Questions,

Project Planning, Scheduling, Monitoring Progress, Assessing Outcomes, and Reflecting on the Learning Experience. The initial draft of the LKPD was created using Microsoft Word and Canva.

## Development Stage

In the development stage, the LKPD was composed based on the design and then subjected to validation to evaluate the feasibility of its content, media, and instructional strategies. Improvements were made based on suggestions from expert validators.

a) Validation Test

The LKPD validation involved three experts: a content expert and a media expert from the Physics Department at Universitas Negeri Medan, and a high school physics teacher as the learning expert.

**Table 7.** Content expert validation results

| Aspect | Average Percentage | Category |
|---|---|---|
| Content presentation | 75% | Valid |
| Material relevance | 85% | Very Valid |
| Graphics | 75% | Valid |
| Readability | 75% | Valid |
| Overall Average Score | 78% | Valid |

**Table 8.** Media expert validation results

| Aspect | Average Percentage | Category |
|---|---|---|
| Media | 75% | Valid |
| Attractiveness | 75% | Valid |
| Design | 75% | Valid |
| Material delivery | 75% | Valid |
| Overall Average Score | 75% | Valid |

**Table 9.** Learning expert validation results

| Aspect | Average Percentage | Category |
|---|---|---|
| Content | 70.8% | Valid |
| PjBL Learning Components | 87.5% | Valid |
| Overall Average Score | 79.1% | Valid |

Based on the validation tests, the content expert rated the LKPD at 78% (Valid), the media expert at 75% (Valid), and the learning expert at 79.1% (Valid). These findings align with previous studies by Dwimardianti (2021), which reported validation scores of 77.8% and 80% for PjBL-based LKPDs. Similarly, Humayroh et al. (2023) reported validity results of 71.5% (content), 75% (media), and 76.3% (learning expert). These consistent findings confirm the feasibility and validity of the developed PjBL-based LKPD for use in physics education.

## Implementation Stage

This stage involved implementing the developed LKPD in a classroom setting. The aim was to test both the practicality and effectiveness of the LKPD. The trial was conducted with 36 students from Grade XI and one physics teacher at SMA Negeri 14 Medan.

a) Practicality Test

**Table 10.** Students' practicality test results

| Aspect | Average Percentage | Category |
|---|---|---|
| LKPD Design | 95.4% | Very Practical |
| LKPD Content Delivery | 90.7% | Very Practical |
| PjBL Components | 90.8% | Very Practical |
| Overall Average | 92.3% | Very Practical |

**Table 11.** Teacher's practicality test results

| Aspect | Average Percentage | Category |
|---|---|---|
| LKPD Design | 87.5% | Very Practical |
| LKPD Content Delivery | 91.6% | Very Practical |
| PjBL Components | 91.6% | Very Practical |
| Overall Average | 90.2% | Very Practical |

The practicality test indicated that the LKPD was highly practical, with students rating it at 92.3% and the teacher at 90.2%. These results support findings by Anggriani et al. (2024), who reported teacher and student practicality scores of 93% and 90%, respectively. Thus, the developed LKPD is deemed highly practical for classroom implementation in physics education.

b) Effectiveness Test

Effectiveness was evaluated using pretest and posttest results, as shown in the Table 12.

**Table 12.** Students' pretest–posttest results

| Test Type | Average Score | N-Gain | Category |
|---|---|---|---|
| Pretest | 37.77 | 0.77 | High |
| Posttest | 86.38 | | |

The N-gain value of 0.77 indicates a high level of effectiveness, showing significant improvement in students' learning outcomes. According to Hake (1999), an N-gain score between 0.70 and 1.00 is considered high. These findings are consistent with studies by Selian et al. (2023), who reported an N-gain of 0.72, and Nurkhasanah et al. (2024), who reported 0.79, both confirming the effectiveness of PjBL-based LKPDs in enhancing learning outcomes.

## Evaluation Stage

In the final stage, the validation, practicality, and effectiveness tests confirmed that the developed PjBL-based LKPD was valid, highly practical, and effective in improving student learning outcomes. The LKPD provided tangible benefits for both teachers and students. Teachers can use it as a printed supplementary learning tool that outlines PjBL steps systematically and can be used without digital devices. Meanwhile, students benefit from a learner-centered experience that helps them understand the PjBL learning syntax thoroughly.

However, one limitation of this study was the inability to incorporate dynamic fluid animation videos into the printed LKPD. This restricted the clarity of certain conceptual explanations in the dynamic fluid material.

## CONCLUSION

This study resulted in the development of a Student Worksheet (LKPD) based on the Project-Based Learning (PjBL) model for the topic of dynamic fluids, designed for Grade XI students at SMA Negeri 14 Medan. Based on the validation results, the PjBL-based LKPD was classified as valid, with scores obtained from the content expert (78%), media expert (75%), and learning expert (79.1%). The practicality test showed that the LKPD was highly practical, with student responses at 92.3% and teacher responses at 90.2%. Furthermore, the effectiveness test—measured through a comparison of pretest and posttest scores—yielded an N-Gain value of 0.77, categorized as high, indicating a significant improvement in students' learning outcomes.

Theoretically, this research reinforces existing findings that the PjBL model is effective in facilitating knowledge construction through investigation, collaboration, and project completion. Practically, the developed LKPD serves as an innovative teaching material that can be utilized by teachers to enhance student engagement, foster scientific literacy, and strengthen problem-solving skills in physics learning. Therefore, the PjBL-based LKPD developed in this study is valid, highly practical, and effective, and is recommended for implementation in physics learning—particularly on the topic of dynamic fluids.

## RECOMMENDATION

This study had certain limitations, particularly in terms of the absence of animated videos to visualize the motion of dynamic fluid concepts within the printed LKPD. Future research is recommended to incorporate animation-based media to optimize conceptual clarity. It is also advised that future researchers carefully review and align the formulation of items in questionnaire indicators to ensure accuracy and consistency in the assessment process.

## ACKNOWLEDGMENT

The author extends sincere gratitude to the thesis advisor, who provided invaluable guidance throughout this research, as well as to the principal, teachers, and students of SMA Negeri 14 Medan for their support and participation in this study.

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