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Development of Electronic Student Worksheets Based on FLIP PDF Using Problem Based Learning Models on Static Fluid Material

Succy Rahma Yurmasri[1], Ratnawulan[1*], Fatni Mufid[1]

[1] Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia
Corresponding author. Email:ratnawulan@fmipa.ac.id

ABSTRACT

Teaching materials are a fundamental component in ensuring the success of educational transformation, particularly within the implementation of Kurikulum Merdeka, which emphasizes active student engagement. However, observations reveal that student worksheets (LKPD) currently used in physics learning are predominantly conventional and lack the structural standards necessary to stimulate thinking skills. This situation contributes to low student learning outcomes, especially in static fluid topics. To address these challenges, this study aims to develop a Flip PDF based E-LKPD integrated with the Problem Based Learning (PBL) model and evaluate its validity and practicality in physics education. This Research and Development (R&D) study utilizes the Plomp development model, comprising three stages: preliminary research, development or prototyping phase, and assessment phase. This research was conducted up to the prototyping phase, specifically through small group trials. Preliminary data were collected via interviews and questionnaires. Subsequently, the product underwent self evaluation and validation by three physics experts from FMIPA UNP. Practicality was assessed using one to one and small group methods with questionnaires, interpreted through a modified Riduwan scale. The findings demonstrate highly positive results: a self evaluation score of 91%, expert validity of 93% (highly valid), and a one to one practicality score of 94%. Furthermore, the small group trial yielded average scores of 93% from students and 99% from teachers, both categorized as highly practical. In conclusion, the PBL based E-LKPD using Flip PDF for static fluid material is proven to be valid and practical, making it feasible for use as an effective learning medium.

Keywords : Electronic Student Worksheets, Flip PDF, Problem Based Learning, Static Fluid

I. INTRODUCTION

Teaching materials are essential components of the learning process, serving as the primary means for content delivery and supporting the achievement of instructional goals. Systematically designed, contextual, and aligned with student characteristics, these materials can significantly enhance instructional quality and student learning outcomes [1], [2]. Theoretically, effective teaching materials should not only contain factual information but also integrate learning activities that foster conceptual understanding, the development of higher-order thinking skills, and student autonomy [3], [4]. This aligns with modern educational philosophy, which views teaching materials not merely as information repositories but as instruments for intellectual stimulation. One widely utilized form of teaching material in schools is the Student Worksheet (LKPD), which functions as a guide for learning activities, ensuring active student engagement through discussion, observation, and experimentation [5]. An ideal LKPD must bridge the gap between abstract theories and practical real-world applications.

Along with the advancement of digital technology, the demands of 21st-century education have driven a transformation from printed to electronic teaching materials. This modern pedagogical approach emphasizes the mastery of critical thinking, creativity, collaboration, and communication skills, which necessitate the integration of technology within the learning process [6], [7]. Technology integration is no longer an option but a necessity to create a learning ecosystem relevant to the current generation. Electronic Student Worksheets (E-LKPD) are designed to provide more interactive content delivery by integrating multimedia element such as images, videos, and animation to assist students in visualizing abstract physics concepts [8]. Furthermore, developing interactive, digital-based E-LKPDs has been reported to enhance student engagement and exploration in physics education, both individually and in groups, without space and time constraints [9].

However, preliminary studies at SMA Negeri 3 Padang indicate that the utilization of LKPDs in physics instruction, particularly regarding static fluid topics, remains suboptimal. Static fluid material possesses unique characteristics, involving concepts such as hydrostatic pressure, Pascal's Law, and Archimedes' Principle, which require robust visual representation. The worksheets currently in use generally contain only technical experimental procedures and observation tables, lacking real-world contexts. This condition has resulted in low learning achievement, with only 18% of students meeting the Learning Objective Achievement Criteria (*Kriteria Ketercapaian Tujuan Pembelajaran* or KKTP), while the majority struggle to visualize physical concepts. Low conceptual understanding is often caused by instructional delivery that fails to relate theory to real-world phenomena [10]. Furthermore, limited access to interactive digital media exacerbates the difficulty students face in comprehending unobservable physical phenomena, leading to persistent misconceptions [11].

One learning model aligned with the requirements of the *Kurikulum Merdeka* (Independent Curriculum) is Problem Based Learning (PBL). The Kurikulum Merdeka calls for differentiated and student-centered learning, which the PBL model accommodates by providing authentic challenges. As an approach that utilizes real world problems, PBL is designed to cultivate problem solving skills while simultaneously constructing students' essential knowledge [12]. This model facilitates students in identifying information needs and evaluating hypotheses collaboratively [13]. The student-centered characteristics of PBL have been proven to provide ample space for discussion and group work, thereby strengthening social interaction within the learning process [14]. Engaging in problem solving discussions encourages students to actively seek information, which positively impacts the enhancement of their learning autonomy [15]. Furthermore, the integration of the PBL model with a scientific approach has proven effective in guiding students to discover concepts independently through structured inquiry [16]. This process simultaneously enables the implementation of authentic assessments that comprehensively encompass attitudes, knowledge, and skills, in accordance with the *Profil Pelajar Pancasila* (Pancasila Student Profile).

To realize the digital integration of the PBL model, a platform capable of dynamic content presentation is required. One platform capable of optimizing the development of interactive E-LKPDs is Flip PDF Professional software. This technology enables the transformation of static documents into digital publications with page flipping effects, integrated with multimedia features such as videos, animations, and interactive navigation. The use of Flip PDF is considered capable of overcoming visualization constraints in static fluid topics by presenting simulations of physical phenomena that are more concrete than conventional printed media. The synergy between the advantages of Flip PDF and the systematic stages of the PBL model is expected to produce teaching materials that are not only technically valid but also practical in improving conceptual understanding and providing greater learning flexibility for students. Based on this urgency, this study aims to develop a Flip PDF Professional Based E-LKPD using the Problem Based Learning (PBL) model for static fluid topics, tested for its validity and practicality. The presence of this innovative teaching material is expected to serve as an effective solution to enhance students' conceptual understanding while supporting the successful implementation of the *Kurikulum Merdeka*.

II. METHOD

This study is a Research and Development (R&D) project employing the Plomp development model. The Plomp model consists of three phases: preliminary research, the prototyping phase, and the assessment phase [17]. The selection of the Plomp model is based on its flexible yet systematic characteristics in solving complex educational problems through the development of tested products. In this study, the research is limited to the second stage, the development or prototyping phase, which includes validity and practicality testing on a limited scale. This limitation is applied because the primary focus of the research is on developing and evaluating the quality of the teaching material instrument before widespread implementation. The subjects of this study are eleventh-grade students at SMAN 3 Padang.

The preliminary research phase was conducted to define the problems and needs for E-LKPD development. This stage involves needs analysis, content analysis, and a literature review. The needs analysis was carried out by distributing questionnaires to 15 students to identify difficulties in physics concepts and preferences for teaching materials, as well as conducting interviews with physics teachers to explore instructional challenges. Additionally, an analysis of existing LKPDs was performed to evaluate their format suitability and content depth relative to the established learning outcomes. The literature review examined articles related to the Problem-Based Learning (PBL) model, Flip PDF applications, and static fluid topics to determine learning outcomes and objectives. The results of this phase serve as the foundation for designing the framework of the product to be developed.

The subsequent stage is the prototyping phase, which encompasses prototype design and formative evaluation. The E-LKPD prototype was structured based on PBL syntax assisted by Flip PDF, integrating video simulations of static fluid phenomena to trigger students' cognitive conflict. The formative evaluation followed Tessmer's formative evaluation framework [17], which consists of: (1) Self-evaluation by the researcher to examine initial completeness and minimize technical errors, such as broken links or typographical errors. (2) Expert review by three physics lecturers from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang (FMIPA UNP), to validate content, construct, design, and linguistic aspects. This validation aimed to ensure that the physics content in the E-LKPD is accurate and does not lead to misconceptions. (3) One-to-one evaluation with three students (representing high, medium, and low academic abilities) to assess readability and ease of use. (4) Small group evaluation involving 27 eleventh-grade students at SMAN 3 Padang to test the product's practicality through direct implementation in the learning process.

The research instruments employed include teacher interview guides, student needs assessment questionnaires, self-evaluation sheets, expert validation sheets, and practicality questionnaires. Each instrument underwent prior validation to ensure the reliability and consistency of the data collected. The obtained data were analyzed using descriptive statistics. Validity and practicality assessments were conducted using a four-point Likert scale, consisting of *strongly disagree*, *disagree*, *agree*, and *strongly agree*. The utilization of four categories without a neutral option aimed to elicit a clearer indication of respondents' attitudes and to mitigate central tendency bias [18]. Furthermore, the scores were analyzed using the percentage formula as proposed by [19], as follows:

$$Score = \frac{total\ obtained\ score}{maksimum\ possible\ score} \times 100\% \qquad (1)$$

The interpretation of the assessment results was adapted from the criteria proposed by [19]. This interpretation serves to provide meaningful qualitative descriptions of the quantitative scores obtained. Each score range is categorized into specific interpretation levels, which are then tailored to the context of each assessment stage. These categories are utilized across all research phases to evaluate the respective evaluation contexts. Ultimately, the results of this analysis determine whether the E-LKPD prototype is feasible for implementation or requires further revision based on feedback from both validators and users.

Table 1. Interpretation of Analysis Results

Persentase (%)	Kategori
0 – 25	Very Poor
25 – 50	Poor
51 – 75	Good
75 – 100	Very Good

(Source: Ref [19])

III. RESULTS AND DISCUSSION

A. Research Result

The study followed the Plomp development model, which comprises three stages: preliminary research, the development or prototyping phase, and the assessment phase. However, this research was limited to the prototyping phase, encompassing validity testing and small-scale (small group) practicality testing.

1. Preliminary Research

This phase aimed to identify field-specific problems through student needs analysis, teacher interviews, and a literature review. The Student Needs Analysis was conducted by distributing questionnaires to 15 eleventh-grade students at SMAN 3 Padang to evaluate the learning process, the use of teaching materials, and digital media requirements. The results indicated high enthusiasm for learning physics (87%); however, 80% of students encountered difficulties in rapid conceptual understanding, and 60% still required additional learning resources beyond teacher explanations. Although all students utilized printed worksheets (LKPD), 47% continued to find physics material difficult to comprehend, indicating that current printed material designs are suboptimal in facilitating conceptual understanding. Regarding learning methods, there was a strong preference for group learning (87%) and independent study (67%). Furthermore, technology integration in assessment remained low, with 60% of students having never experienced interactive digital-based evaluations. These conditions confirm the necessity for innovation through the development of interactive and engaging E-LKPDs that integrate multimedia to enhance conceptual understanding, active engagement, and student learning autonomy, in alignment with current instructional technology demands.

Teacher interviews revealed that while the school has implemented the Kurikulum Merdeka (Independent Curriculum) with structured instructional tools, teaching materials remain dominated by printed formats (textbooks and independent worksheets) that lack an ideal structure and interactive digital integration. In practice, teachers tend to employ the Discovery Learning model for eleventh-grade topics due to the extensive curriculum coverage, including static fluids, which students perceive as difficult. Another constraint is the limited laboratory facilities relative to the number of classes; when schedules overlap, one class is often forced to replace practical activities with static videos from YouTube or PowerPoint presentations. Although teachers have attempted to relate physics concepts to real-world phenomena, current printed LKPDs have not fully facilitated active student engagement or autonomy in exploring abstract concepts. Consequently, teachers responded positively to the development of E-LKPDs based on Flip PDF Professional. This medium is considered capable of providing interactive and engaging digital simulations, thereby facilitating the visualization of complex topics without relying solely on the availability of laboratory equipment.

The literature review was conducted by analyzing various reference sources regarding the curriculum, the characteristics of static fluid topics, and relevant learning models. The findings indicate that static fluid is a complex and fundamental topic in physics education. However, it is also identified as a subject that presents significant difficulties for students in conceptual understanding. These difficulties are generally influenced by students' daily experiences that do not align with scientific concepts, often leading to persistent misconceptions [20]. Therefore, concrete visual representations through interactive media are required to minimize these comprehension barriers. Furthermore, a review of the Problem-Based Learning (PBL) model confirms its effectiveness in enhancing problem-solving skills, particularly when supported by teaching materials that facilitate independent inquiry [12]. These literature findings reinforce the urgency of developing interactive E-LKPD is as a solution to bridge the gap between abstract theory and real-world phenomena in physics education.

2. Development or Prototyping Phase

The developed prototype consists of an E-LKPD based on Flip PDF, integrated with the Problem-Based Learning (PBL) model for static fluid topics. The design adapts the Ministry of Education and Culture's ICT-based teaching materials development guidelines comprising key components: cover, identity, learning instructions, learning outcomes and objectives, learning activities aligned with PBL syntax, evaluation, and references. [7]

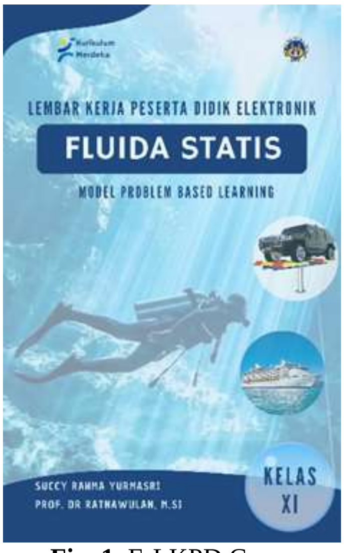

Fig. 1. E-LKPD Cover

This stage began with a self-evaluation to ensure the initial quality of the product. The researcher conducted a thorough review of component completeness, corrected typographical errors, and ensured the functionality of digital features. The self-evaluation results yielded an average score of 91%, with the following breakdown: ICT structure suitability (91%), PBL syntax (90%), Flip PDF features (94%), linguistic aspects (88%), and visual display (94%). These figures indicate that the developed product met the initial feasibility criteria and was ready for expert validation.

The subsequent stage involved an expert review by three validators from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. This process resulted in an average validity score of 93%, categorized as 'Highly Valid' according to Riduwan [19]. Specifically, the instructional design and visual communication indicators achieved the highest score of 97%, while material substance and software utilization both scored 92%, and the integration of the PBL model scored 89%. Despite being declared valid, several revisions were made based on the validators' suggestions, including: (1) refining the Learning Outcomes (CP) for better focus; (2) strengthening problem orientation through more contextual phenomenon videos; (3) repositioning basic theory as a summary; and (4) clarifying instructions during the investigation and problem-solving analysis stages. The final product from this stage was deemed feasible for practicality testing.

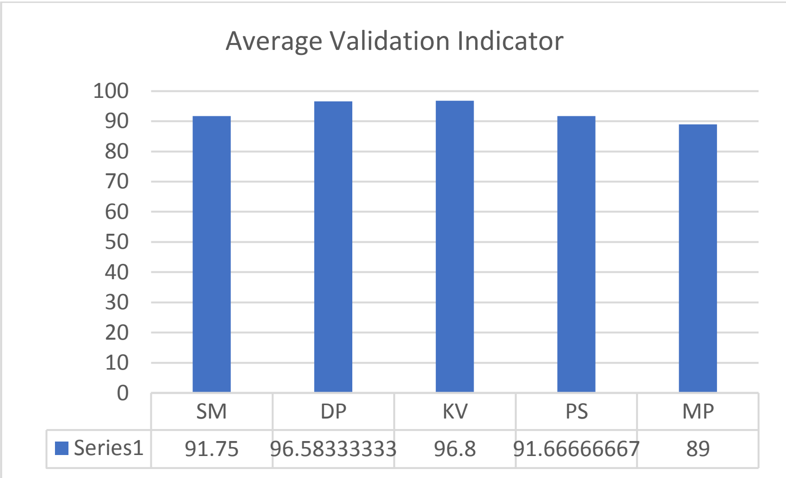

Fig. 2. E-LKPD Validation Results

A one-to-one practicality test was conducted with three students from SMAN 3 Padang (representing high, medium, and low academic abilities) to assess the E-LKPD from the user's perspective. The assessment instrument covered three main indicators: content, display and media, and ease of use. The analysis showed an average practicality score of 94%, categorized as 'Highly Practical.' Specifically, the content indicator scored 93%, display and media reached the highest score of 98%, and ease of use scored 93%. Based on student feedback, the E-LKPD provided an engaging, enjoyable, and easy-to-understand learning experience. As the suggestions provided were reinforcing and no fundamental weaknesses were found, no revisions were made at this stage, and the product was declared feasible for the next research phase.

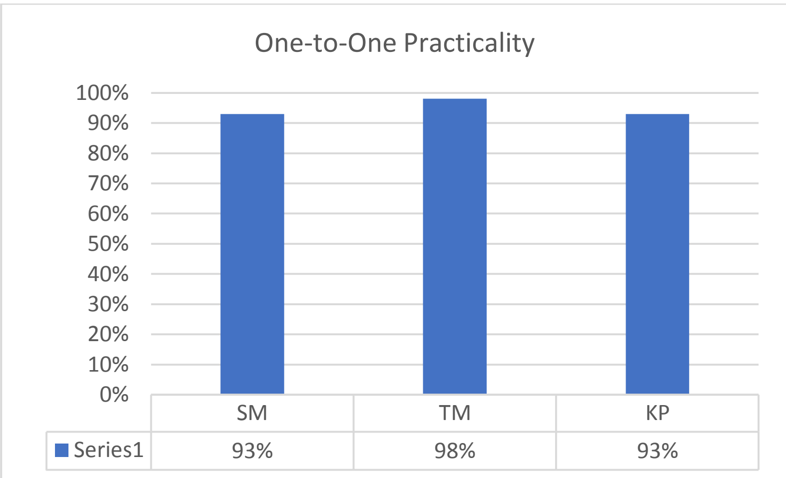

Fig. 3. One-to-One Practicality Results

A small group practicality test was carried out involving 27 students at SMAN 3 Padang to evaluate the implementation of the Flip PDF-based E-LKPD using the PBL model. The assessment, conducted via questionnaires, included three primary indicators: material substance, display and media, and ease of use. Based on the analysis, the E-LKPD obtained an average practicality score of 93%, categorized as 'Highly Practical.' In detail, material substance scored 92%, display and media 94%, and ease of use 93%. These results demonstrate that the product provides engaging learning media, accurate instructions, and accessible navigation that optimally supports students' conceptual understanding.

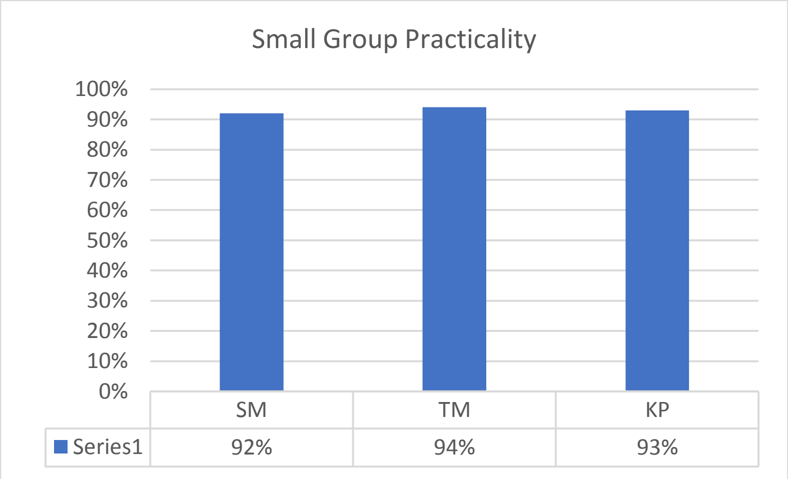

Fig. 4. Small Group Practicality Results

The researcher also involved a Physics teacher as an evaluator to assess the product's practicality from an educator's perspective. This assessment aimed to ensure the effectiveness of the E-LKPD as a functional instructional tool for managing classroom activities. The teacher's evaluation during the small group phase covered material substance, media display, and ease of use. The teacher's involvement serves to strengthen the product's practicality validity, ensuring the E-LKPD is not only feasible for the student's learning experience but also functional for educators.

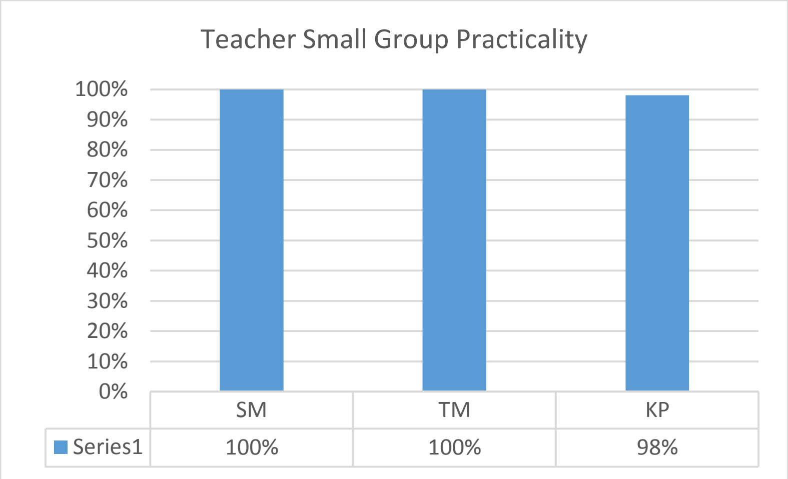

Fig. 5. Teacher Small Group Practicality Results

The developed prototype consists of an E-LKPD based on Flip PDF, integrated with the Problem-Based Learning (PBL) model for static fluid topics. The design adapts the Ministry of Education and Culture's ICT-based teaching materials development, comprising key components: cover, identity, learning instructions, learning outcomes and objectives, learning activities aligned with PBL syntax, evaluation, and references.

B. Discussion

This Research and Development (R&D) study employed the Plomp development model, comprising the preliminary research and the development or prototyping phases, to produce a Flip PDF-based E-LKPD integrated with the Problem-Based Learning (PBL) model for static fluid topics. The analysis during the preliminary research phase, conducted through questionnaires and interviews, revealed a significant gap between ideal instructional conditions and field realities. Although student enthusiasm for physics is relatively high (87%), this does not correlate with conceptual understanding, as 80% of respondents reported difficulties and required more time to master the material. This condition is exacerbated by low average scores in the Summative Assessment of Material Scope (SLM), which fall below the Minimum Mastery Criteria (KKM), necessitating remedial teaching. The primary cause is the reliance on conventional printed teaching materials that lack an ideal structure and fail to visualize abstract phenomena. Consequently, 47% of students continued to struggle despite using school-issued worksheets, and 67% were forced to seek independent supplementary resources online. Furthermore, a lack of innovation is evident from the fact that 60% of students had never engaged in interactive digital-based evaluations.

Although teachers implemented the Discovery Learning model for time efficiency, the lack of digital teaching materials resulted in a monotonous learning experience. In response to these constraints, the development of a Flip PDF Professional-based E-LKPD integrated with the PBL model emerged as a solution fully supported by educators. Such instructional innovation aligns with findings in science education indicating that the use of visual representations and concrete learning media significantly assists students in comprehending abstract physics concepts and reducing misconceptions. This is attributed to the fact that visualization provides a tangible depiction of phenomena that cannot be directly perceived, such as the concepts of pressure and buoyant force in static fluids [21]. Furthermore, the utilization of visual media supports the development of problem-solving skills through more active exploration and independent inquiry [22]. By integrating digital practical simulations and PBL syntax, this E-LKPD is expected to transform static documents into interactive media that is contextual, collaborative, and relevant to the demands of the Kurikulum Merdeka (Independent Curriculum).

The literature review was conducted by analyzing various reference sources regarding the curriculum, the characteristics of static fluid topics, and relevant learning models. The findings indicate that static fluid is a complex and fundamental topic in physics education. However, it is also identified as a subject that presents significant difficulties for students in conceptual understanding. These difficulties are generally influenced by students' daily experiences that do not align with scientific concepts, often leading to persistent misconceptions [20]. Therefore, concrete visual representations through interactive media are required to minimize these comprehension barriers. Furthermore, a review of the Problem-Based Learning (PBL) model confirms its effectiveness in enhancing problem-solving skills, particularly when supported by teaching materials that facilitate independent inquiry [12]. These literature findings reinforce the urgency of developing interactive E-LKPD is as a solution to bridge the gap between abstract theory and real-world phenomena in physics education.

The prototyping phase began with the design of the Flip PDF-based E-LKPD, followed by formative evaluations (self-evaluation, expert review, one-to-one, and small group). The self-evaluation results reached the "Very Good" category, as the design complied with ICT-based teaching material development guidelines, systematically integrated the five PBL syntaxes, and met linguistic and visual standards. The integration of the PBL model aims to improve learning quality and engagement by guiding students to think critically, analyze problems, and relate scientific concepts of static fluids to real-world daily phenomena.

The validation phase was conducted by three experts from the Physics Department, FMIPA UNP, to assess product feasibility before field testing. Overall, the Flip PDF-based E-LKPD with the PBL model was declared "Highly Valid" with an average score of 93%. This achievement resulted from a formative evaluation process involving product refinements based on expert feedback. Specifically, the instructional design and visual communication indicators achieved the highest scores of 97%, indicating that all material components and aesthetic aspects—such as navigation, typography, and layout were proportionally designed to increase student interest. The material substance indicator reached 92%, proving that the content met conceptual accuracy and currency requirements while aligning with the Kurikulum Merdeka. Technically, software utilization scored 92% through the integration of Canva, Flip PDF, and Google Form based assessment instruments, creating an interactive digital learning ecosystem. Finally, the PBL model integration scored 89%, confirming that the E-LKPD successfully integrated problem-based syntax to foster critical thinking and real-world problem-solving. This aligns with efforts to realize the Profil Pelajar Pancasila (Pancasila Student Profile) through daily life contexts embedded in the material. Overall, the combination of pedagogical aspects and technological sophistication ensures that the E-LKPD is ready for use as an effective and meaningful medium.

The final stage was practicality testing to ensure the developed E-LKPD was feasible and met field needs. This test consisted of two main stages: one to one and small group evaluations. The one-to-one test involved three students representing high, medium, and low academic abilities. Results showed a very high level of practicality, with the material substance indicator scoring between 92% and 94%. The display and media indicator scored 93% from the high ability student and reached a perfect 100% from the medium and low-ability students, while ease of use ranged from 92% to 94%. These achievements placed the product in the "Highly Practical" category, with average scores of 92% (high), 95% (medium), and 96% (low). This demonstrates that the E-LKPD is visually appealing and easily operated by students with diverse characteristics.

Feedback from students across all ability levels was overwhelmingly positive. High-ability students stated that the E-LKPD was easy to comprehend and provided a unique, engaging, and flexible learning experience accessible anytime and anywhere. Similarly, medium and low-ability students expressed that the learning process became more enjoyable and understandable. These testimonials prove that the developed media is not only visually superior but also highly functional in supporting practical and interactive learning.

The small group practicality test involved 27 students and a physics teacher at SMAN 3 Padang. The results showed a very high level of practicality, with the material substance indicator scoring 92% from students and 100% from the teacher. The display and media indicator scored 94% from students and 100% from the teacher, while ease of use reached 93% from students and 98% from the teacher. Overall, the small group practicality average reached 93% from students and 99% from the teacher. This confirms that the Flip PDF-based E-LKPD meets all criteria for practicality, ease of operation, and field relevance. Having met both validity and practicality standards, this E-LKPD is declared highly feasible for physics instruction and ready to proceed to the product effectiveness testing stage.

IV. CONCLUSION

Based on the entire series of research and development processes, it can be concluded that the E-LKPD based on Flip PDF Professional integrated with the Problem-Based Learning (PBL) model for static fluid material for grade XI high school students meets the criteria for high-quality teaching materials in terms of validity and practicality. This product was developed through a systematic procedure referring to the Plomp development model, which includes the preliminary research and development or prototyping phases. The limitation of the research to these first two stages has successfully resulted in a final prototype that is theoretically and practically tested, possessing full readiness to proceed to the assessment phase on a broader implementation scale.

The evaluation results from three expert validators indicate a validity level of 93% (Highly Valid). This achievement encompasses an accumulation of assessments in the aspects of material substance, instructional design, visual communication, software utilization, and the integration of PBL syntax. This provides empirical evidence that the content within the E-LKPD is scientifically accurate and aligned with the requirements of the Merdeka Curriculum, which emphasizes the depth of conceptual understanding. Furthermore, the product has met the criteria for being highly practical, with scores of 94% in the one-to-one evaluation and 93% in the small group evaluation from the students' perspective, as well as 99% from the teachers' perspective. These figures prove that the Flip PDF Professional navigation is highly intuitive and functional in supporting student-centered learning.

The primary advantage of this E-LKPD lies in the collaboration between interactive multimedia integration and the systematic stages of the PBL model. The utilization of Flip PDF Professional enables the presentation of real-world phenomenon videos and digital navigation that provides a concrete learning experience for students, thereby bridging the understanding of abstract static fluid concepts. Nevertheless, this study has limitations as it is still restricted to small-scale validity and practicality testing without directly measuring the impact on learning outcomes through a field test. Therefore, future research is recommended to proceed to the assessment phase through classroom effectiveness testing to comprehensively measure the influence of E-LKPD usage on the improvement of students' conceptual understanding, problem-solving skills, and cognitive learning outcomes. Further research could also be developed to cover other physics topics to create sustainable digitalization of high-quality teaching materials in secondary education units.

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REFERENCES

[1] A. H. Hernawan, Permasih, dan L. Dewi, *Pengembangan Bahan Ajar Tematik*. 2012. [Daring]. Tersedia pada: http://file.upi.edu/Direktori/FIP/JUR._KURIKULUM_DAN_TEK._PENDIDIKAN/194601291981012-PERMASIH/PENGEMBANGAN_BAHAN_AJAR.pdf

[2] A. Prastowo, *Panduan Kreatif Membuat Bahan Ajar Inovatif*. Yogyakarta: Diva Press, 2015. [Daring]. Tersedia pada: https://id.scribd.com/document/564725915/Panduan-Kreatif-Membuat-Bahan-Aja-Inovatif

[3] D. R. Anderson, L. W., & Krathwohl, *Kerangka Landasan untuk Pembelajaran, Pengajaran dan Assesmen*. 2010. [Daring]. Tersedia pada: https://fliphtml5.com/omxke/mkbx/basic

[4] Trianto, *Model Pembelajaran Terpadu: Konsep, Strategi, dan Implementasinya.* Jakarta: Bumi Aksara, 2010. [Daring]. Tersedia pada: https://books.google.co.id/books?id=XTYVEQAAQBAJ&printsec=frontcover&hl=id&source=gbs_book_other_versions_r&cad=3#v=onepage&q&f=false

[5] S. M. Noprinda, C. T., & Soleh, "Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Problem Based Learning," *Indones. J. Sci. Math. Educ.*, vol. 02, no. 2, hal. 168–176, 2019.

[6] B. Trilling dan C. Fadel, *21 st Century Skills: Learning For Life our Time*. 2009.

[7] D. T. R. I. Badan Standar, Kurkulum, Dan Asesmen Pendidikan Kementrian Pendidikan, Kebudayaan, Riset, *Dimensi, Elemen, dan Subelemen Profil Pelajar Pancasila pada Kurikulum Merdeka*. 2022.

[8] F. R. Palupi dan P. Pujianto, "Pengembangan lembar kerja peserta didik elektronik (E-LKPD) berbasis multimedia guna meningkatkan penguasaan materi fisika Dan kemandirian belajar peserta didik SMA," *Jur. Pendidik. Fis. Univ. Negeri Yogyakarta*, hal. 1–10, 2021.

[9] D. A. Wati, L. Hakim, dan L. Lia, "Development of Newton Law Interactive E-Lkpd Based on Mobile Learning Using Live Worksheets in High School," *J. Pendidik. Fis.*, vol. 10, no. 2, hal. 72, 2021, doi: 10.24114/jpf.v10i2.26567.

[10] F. Mufit, F. Festiyed, A. Fauzan, dan L. Lufri, "Impact of Learning Model Based on Cognitive Conflict toward Student's Conceptual Understanding," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 335, no. 1, 2018, doi: 10.1088/1757-899X/335/1/012072.

[11] Y. Fauzana, Ratnawulan, dan Usmeldi, "The effectiveness of physics learning materials using problem-based learning model integrated with local wisdom," *J. Phys. Conf. Ser.*, vol. 1185, no. 1, 2019, doi: 10.1088/1742-6596/1185/1/012087.

[12] R. I. Arends, *Learning to Teach (9th ed.)*. McGraw-Hill, 2012.

[13] M. Fathurrohman, *Model-Model Pembelajaran Inovatif: Alternatif Desain Pembelajaran yang Menyenangkan*. Yogyakarta: Ar-Ruzz Media, 2015.

[14] R. Puspitasari, F. Mufit, dan Asrizal, "Conditions of learning physics and students' understanding of the concept of motion during the covid-19 pandemic," *J. Phys. Conf. Ser.*, vol. 1876, no. 1, 2021, doi: 10.1088/1742-6596/1876/1/012045.

[15] S. G. Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kassa, "The Effect of Problem Based Learning (PBL) Instruction on Students' Motivation and Problem Solving Skills of Physics," *Eurasia J. Math. Sci. Technol. Educ.*, 2017, [Daring]. Tersedia pada: https://www.ejmste.com/article/the-effect-of-problem-based-learning-pbl-instruction-on-students-motivation-and-problem-solving-4694

[16] M. Mutia, A. S. Budi, dan V. Serevina, "Pengembangan Perangkat Pembelajaran Fisika Sma Berbasis Problem Based Learning," *Pros. Semin. Nas. Fis.*, hal. 169–184, 2014.

[17] T. Van den Akker, J., Bannan, B., Kelly, A. E., Nieveen, N., & Plomp, *Educational Design Research*. 2013. [Daring]. Tersedia pada: http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ815766

[18] S. O. Leung, "A comparison of psychometric properties and normality in 4-, 5-, 6-, and 11-point likert scales," *J. Soc. Serv. Res.*, vol. 37, no. 4, hal. 412–421, 2011, doi: 10.1080/01488376.2011.580697.

[19] Riduwan, *Dasar-Dasar Statistika*. Bandung: Alfabeta, 2014.

[20] W. I. Puspita, S. Sutopo, dan L. Yuliati, "Identifikasi penguasaan konsep fluida statis pada siswa," *Momentum Phys. Educ. J.*, vol. 3, no. 1, hal. 53–57, 2019, doi: 10.21067/mpej.v3i1.3346.

[21] G. Rachman dan J. R. Batlolona, "Multirepresentation in Physics Learning to Reduce Students' Misconceptions About Circular Motion Concepts," *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, vol. 13, no. 4, hal. 1035–1052, 2025, doi: 10.33394/j-ps.v13i4.16608.

[22] S. S. Schoenherr, Johanna, Anselm R. Strohmaier, "Learning with visualizations helps: A meta-analysis of visualization interventions in mathematics education," 2024, [Daring]. Tersedia pada: https://www.sciencedirect.com/science/article/pii/S1747938X24000484