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Validity of a Project Based Learning Based Physics Teaching Module on Dynamic Fluids to Enhance Students' Creative Thinking

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ABSTRACT

This study develops a physics teaching module based on Project-Based Learning (PjBL) integrated with a deep learning approach to improve students' creative thinking in dynamic fluid concepts. The development addresses the limited exploration and investigative learning opportunities caused by teacher-centered instruction. The research employed a Research and Development (R&D) design using the 4D model (Define, Design, Develop, and Disseminate), with implementation focused on the Develop stage. Three expert validators assessed the module's validity, while practicality was evaluated through One to One and Small Group Evaluations involving eleventh-grade students. Validation scores were 80% to 100%, which means very high validity in form of content correctness, presentation good appearance, and language design. Utility percentage scores were as high as 89.63% and 91.8%, which was rated very useful. These results demonstrate that the module is user friendly, fun and useful to lead students through project work with supported reflection tasks. This makes the module as a valid teaching materials and easy to use in Merdeka Curriculum.

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1. INTRODUCTION

Creative thinking is a higher-order thinking ability that plays an important role in physics learning because it enables students to investigate concepts, generate ideas, and solve scientific problems. Recent findings emphasize that learning environments that support inquiry and flexibility significantly contribute to the development of creative thinking in physics classrooms (Fitriani et al., 2022). Nonetheless, secondary school physics instruction remains predominantly didactic, relying heavily on routine problem exercises and lecturing, which limits opportunities for exploration and investigation. As a result, students' creativity and conceptual understanding are generally still low, including in dynamic-fluid topics that require strong analytical reasoning. Research shows that many students struggle to connect fluid concepts with real-world phenomena when learning materials are not contextualized or inquiry-oriented (Dhanil & Putri, 2024).

Dynamic fluid concepts such as flow rate, continuity equation, and Bernoulli's principle involve abstract relationships between pressure, velocity, and height, making conceptual reasoning essential. These challenges are compounded when instruction does not involve hands-on experimentation or reflective learning processes. Empirical findings further indicate that students' analytical abilities in dynamic fluids are still far from optimal. Amin Mustajab (2024) reported that 79% of students fall within the low category of critical thinking when learning dynamic fluid material through online e-modules, as many struggle to identify problems, connect concepts, and justify scientific reasoning. These results reinforce the need for instructional materials that facilitate reflective thinking, conceptual reasoning, and active investigation.

Project-Based Learning (PjBL) has increasingly been recognized as a meaningful approach for cultivating higher-order thinking, especially when students engage in structured project tasks. Ramadhani et al. (2024) found that PjBL strengthens students' critical thinking as they explore problems, plan solutions, and collaborate during investigations. Likewise, Ningsih et al. (2020) reported that authentic project activities allow students to develop ideas creatively and reflect on alternative solutions. Physics learning materials designed with the PjBL approach have also been shown to be valid and practical for classroom implementation (Rahmadini et al., 2024). Integrating PjBL with deep-learning principles offers a stronger foundation for conceptual understanding. Deep learning encourages students not only to complete project tasks but also to uncover the scientific meaning behind each stage of the project. Through reflection, concept mapping, and analysis of experimental results, students are guided to relate dynamic-fluid concepts to real situations more meaningfully (Roslina, Achmad Samsudin, 2022)

Although Project-Based Learning (PjBL) has been widely applied in physics education, most existing studies focus on general physics content or static fluid topics rather than dynamic fluids Octapera & Mahtari (2024). Previous research has shown that PjBL can improve students' creative thinking and learning engagement through authentic project activities Ningsih et al. (2020). Several studies have also reported that PjBL-based physics teaching materials are valid and practical for classroom implementation Ramadhani et al. (2024). However, many of these studies emphasize project completion and product outcomes without explicitly integrating deep learning principles that support reflection, concept connection, and meaningful understanding during the learning process (Roslina, Achmad Samsudin, 2022). In addition, research that specifically develops PjBL-based physics teaching modules for dynamic fluid topics aligned with the Merdeka Curriculum remains limited. Therefore, this study differs from previous PjBL or STEM-PjBL module developments by integrating deep learning strategies into a PjBL-based physics teaching module on dynamic fluid concepts, with a specific focus on enhancing students' creative thinking skills.

2. METHODS

This study employed a Research and Development (R&D) method to produce a PjBL-based physics teaching module with a deep learning approach on dynamic fluid concepts. The development process followed the 4D model (Define, Design, Develop, and Disseminate), which has been widely validated in recent studies. Nur Ihsan, Nasruddin (2023) demonstrated that the 4D model offers a structured workflow that yields highly valid instructional products. Angelia et al. (2023) further confirmed its suitability for developing physics modules that are contextually relevant and feasible for classroom use. Likewise, Navila et al., (2023) highlighted the model's effectiveness in supporting the systematic design of PjBL-based learning materials. In this study, the development process was limited to the Develop stage, as the primary objective of the research was to examine the validity and practicality of the developed physics teaching module. At this stage, the focus of the research was on expert validation and limited-scale trials to ensure that the module met the required quality standards in terms of content accuracy, presentation, language, and usability. The Disseminate stage of the 4D development model involves large-scale implementation and effectiveness testing that requires a broader sample size and longer research duration. Therefore, the Disseminate stage was not included in this study and is

positioned as a direction for future research to examine the effectiveness of the module in improving students' learning outcomes and creative thinking skill. The study was conducted during the first semester of the 2025/2026 academic year at SMA Yadika Baturaja with three expert validators (content, media, and language) and 12 eleventh-grade students. Three students participated in the One-to-One Evaluation and nine in the Small Group Evaluation. The resulting product is a 21-page teaching module containing learning objectives, conceptual explanations, project stages, LKPD, assessment instruments, and deep learning-oriented reflection sheets. The stages of the 4D development model are shown in Figure 1 (Kurnia et al., 2024).

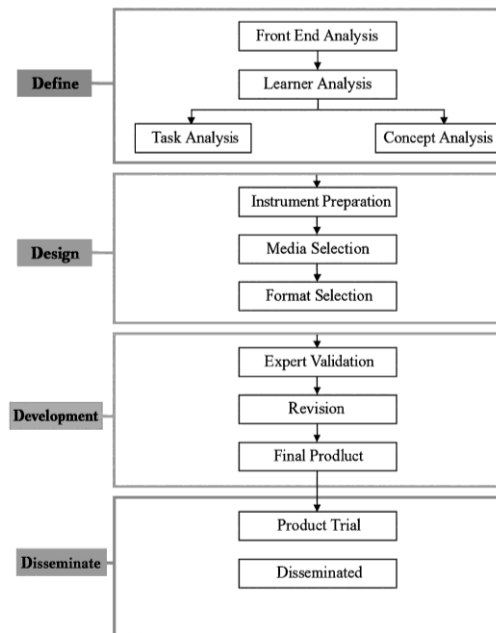


Figure 1. Stages of the 4D Development Model

During the Define stage, the research team examined the curriculum, reviewed students' characteristics, and mapped the essential parts of the dynamic-fluid material. This step helped ensure that the module being developed matched the expected learning outcomes, the level of difficulty of the concepts, and the actual needs of the learners. In the Design stage, the basic structure of the module was drafted by referring to the PjBL sequence starting from introducing the problem, guiding students in planning, carrying out project work, presenting the final product, and ending with reflection. Elements of deep learning were added here as well, particularly through reflective prompts and concept-mapping tasks so students could more easily connect ideas such as pressure, velocity, and fluid height in real situations.

The Develop stage centered on expert reviews and small-scale trials. Three experts, consisting of one specialist in physics content and two physics teachers, evaluated the module using a Likert-based instrument that examined content accuracy, presentation, language, layout, and deep learning features. The validation instrument consisted of several assessment aspects, including content feasibility, presentation and learning strategies, language clarity, graphic design, implementation of the Project-Based Learning model, assessment components, and relevance to student characteristics. Each indicator was rated using a scale to determine the level of validity, and the results were converted into percentage scores. The interpretation of the validity level followed the criteria presented in Table 1 to ensure consistency and transparency in the validation process. Once the module was deemed valid, it was tried out with students through limited-scale evaluations. Three learners with different academic abilities participated in the One-to-One Evaluation, while nine learners were involved in the Small Group

Evaluation. The validity results were then processed descriptively and quantitatively using percentage calculations based on the formula proposed by (Yudiarani & Ardhuha, 2022).

$$V = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\% \quad (1)$$

The validity of the learning materials is assessed based on the criteria outlined and interpreted in Table 1.

Table 1. Criteria for Assessing the Validity of the Teaching Module (Indrawati et al., 2025)

No	Validity Criteria (%)	Validity Level
1	85.01% – 100%	Very valid, usable without revision
2	70.01% – 85%	Valid enough, usable with minor revisions
3	50.01% – 70%	Less valid, not recommended for use due to major revisions needed
4	01.00% – 50%	Invalid, not suitable for use

Overall, the methodological design of this study was aligned with the research objectives, which focused on producing a valid and practical PjBL-based physics teaching module before proceeding to large-scale implementation.

3. RESULT AND DISCUSSION

The Design stage in developing this module used a PjBL syntax consisting of problem orientation, planning, implementation, report preparation, and reflection. Dynamic fluid concepts in the module were then structured in a progressive manner and linked to real life phenomena. The deep learning approach is applied through reflective activities and concept mapping to enhance the students' skills in relationship building among physics variables. Integration of both approaches concurs with Maulida (2022), who outlines the importance of deep learning in building conceptual understanding. The first draft of the module was 54 pages in length, consisting of learning objectives, conceptual descriptions, steps for the project, worksheets or LKPD, and authentic assessment tools. Three experts—a content expert, media expert, and language expert—conducted the validation. The percentage scores obtained ranged from 80% to 100%, and thus fell within the category of 'very valid'. These scores were highest for the feasibility of the content and the accuracy of the material presentation, indicating that the structure was relevant, along with the illustrations and sequencing of concepts for the characteristics of dynamic fluid material. These findings support the view of Wasilah (2024) that a structured presentation enhances readability and clarity in teaching materials.

Practicality testing was carried out in two stages, starting with a One-to-One Evaluation and followed by a Small Group Evaluation. In the first stage, the module received a score of 89.63%. When tested again in a small group, the score rose to 91.8%. Both results placed the module in the “very practical” category. Student responses indicated that the module had high readability, clear instructions, and visual design elements that supported smooth project implementation. These results are aligned with the findings of (Damayanti et al., 2024), who reported that PBL-based physics modules enhance student engagement and facilitate hands-on learning experiences during project activities. The clarity of instructions and the structured design also supported students in completing each project stage, consistent with (Helmi Putri Sulastri, Asep irvan Irvani, 2024), who emphasized that digital PjBL modules improve learning flow through well-organized content and supportive visual features. Taken together, the validity and practicality findings show that the module fits the needs of current learning practices, supports the principles of the Merdeka Curriculum, and helps students build a stronger understanding of dynamic fluid concepts while encouraging creative thinking through structured project activities.

The PjBL model employed in the module's creation adheres to the structure advised by the Ministry of Education, Culture, Research, and Technology (Muhibullah et al., 2024). Each phase of the PjBL implementation was tailored to suit the attributes of dynamic fluid concepts and structured to deliver supported project encounters. The relationship between the PjBL syntax and its application in the module is presented in Table 2.

Table 2. Alignment of the Teaching Module with the PjBL Syntax

PjBL Stage	Implementation in the Physics Teaching Module
Identifying essential questions	The teacher presents real-world phenomena, such as water jets from a bottle or Heron's fountain, and provides guiding questions to stimulate students' curiosity.
Designing project planning	Students design simple experimental tools (e.g., Heron's fountain), determine materials and equipment, identify variables, and plan experimental procedures.
Developing a project schedule	Students set a work schedule, distribute tasks, and determine completion targets for each stage of the project.
Monitoring project activities	The teacher guides the experimental process, observes students' progress, and provides feedback.
Testing the project results	Students demonstrate their devices, collect data on water jet height, and analyze the relationship between pressure and velocity using Bernoulli's principle.
Reflecting on the learning experience	Students engage in deep reflection using reflection sheets, document key findings, and discuss the application of fluid concepts in daily life.

The creative thinking skills developed in this study refer to four indicators of creative thinking fluency, flexibility, originality, and elaboration as outlined by (Nadhiroh et al., 2023). These indicators were used to assess the extent to which the project activities in the module contributed to students' creative thinking skills. The detailed indicators are presented in Table 3.

Table 3. Indicators of Creative Thinking Skills (adapted from Nadhiroh et al. (2023))

Indicator	Sub-Indikator
Fluency	Generating multiple ideas or solutions to physics problems and being sensitive to conceptual errors.
Flexibility	Proposing various alternative solutions and identifying relationships among concepts from different perspectives.
Originality	Producing unique, uncommon, and innovative ideas or experimental designs.
Elaboration	Developing ideas in detailed ways to produce logical and applicable physics solutions.

Furthermore, the connection between the PjBL stages and the indicators of creative thinking skills in the dynamic fluid topic is outlined in Table 4. This pattern is consistent with the findings of Qiara (2024), who demonstrated that each phase of PjBL corresponds to key indicators of creativity fluency, flexibility, originality, and elaboration in science learning (Qiara, 2024).

Table 4. Relationship Between the PjBL Model and Creative Thinking Indicators in Dynamic Fluid Concepts

PjBL Stage	Integrated Creative Thinking Indikator
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Identifying essential questions	Students identify various possible causes of a phenomenon (Fluency).
Designing project planning	Students design alternative apparatus to test the continuity principle or Bernoulli's principle (Flexibility).
Developing a project schedule	Students organize work plans and develop strategies to complete the project (Elaboration).
Monitoring project activities	Students attempt experimental variations, such as changing hole size or water volume (Originality).
Testing the project results	Students describe the relationship between experimental data and Bernoulli's principle in a structured manner (Elaboration) and interpret the phenomenon using new approaches (Originality).
Reflecting on the learning experience	Students reflect on the effectiveness of the solution, evaluate the ideas used, and develop alternative ones (Flexibility & Fluency).

Integrating creative thinking skills into every stage of the PjBL syntax is aimed at ensuring that students do more than simply complete the project steps. The approach encourages them to think reflectively and contextually. With the support of deep learning, students are guided to examine the phenomena they observe, link ideas across different physics concepts, and build new understandings that are more meaningful. The combination of PjBL and creative thinking indicators is expected to deepen students' comprehension of dynamic fluid concepts while cultivating their scientific curiosity. During the Develop phase, the module went through a validation process involving three experts experienced in innovative learning and teaching material development. Following their review, several revisions were made based on the suggestions provided. These revisions included improving the clarity and quality of the illustrations, adjusting the number of meetings to better match the available learning time, and refining the writing to meet the Indonesian Spelling System (EBI) standards. Figures 2 and 3 show a comparison of the module before and after the revisions were applied.

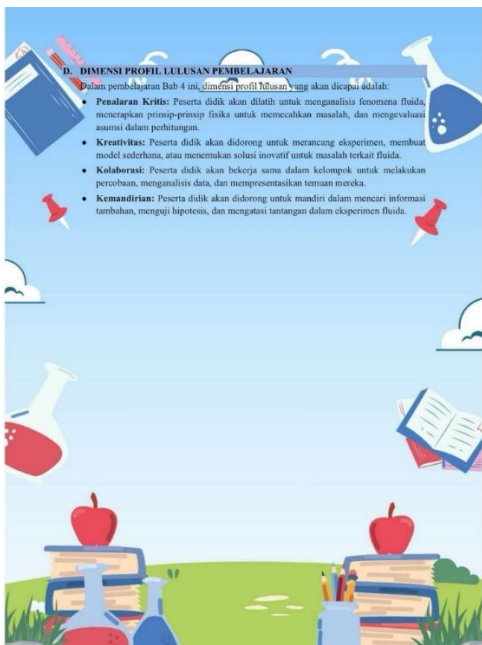


Figure 2. Profile Dimensions Before Revision

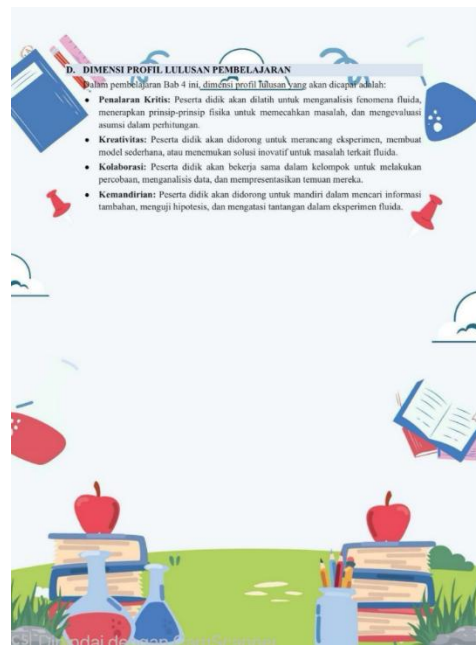


Figure 3. Profile Dimensions After Revision

The physics teaching module developed under the Merdeka Curriculum and deep learning framework is expected to meet certain construction principles to serve as an effective learning resource.

In its design, the module incorporates essential and contextual content that aligns with targeted learning outcomes. The material is presented in a way that connects with students' everyday experiences, allowing them to build concepts more meaningfully. Its structure is arranged systematically and logically, with interconnected ideas that help reinforce deeper conceptual understanding. The module was also tailored to match students' developmental levels so that the learning process remains appropriately challenging without becoming overwhelming. A student-centered perspective guided the development, considering learners' characteristics, interests, and varied learning styles. Technology was integrated where needed to broaden access to learning resources and encourage greater learner autonomy. An evaluation component is included as well, enabling teachers to track both the mastery of learning objectives and the growth of students' creative thinking skills (Yolanda, 2024). A summary of the module's validity scores from the three expert validators is presented in Table 5.

Table 5. Teaching Module Validity Results

No	Assessed Aspect	Validator			Total	Validity	
		A	B	C		Score	Category
A. Content Feasibility of Physics Material							
1	The material covers the core concepts of dynamic fluids (flow rate, continuity, Bernoulli) in accordance with the Phase F Learning Outcomes of the Merdeka Curriculum.	5	5	5	15	100	Very Valid
2	Concepts are presented accurately, scientifically, and aligned with physics principles.	4	4	4	12	80	Quite Valid
3	The material is relevant to real-life phenomena experienced by students.	5	5	5	15	100	Very Valid
4	There is a logical connection among flow rate → continuity → Bernoulli → real-world applications.	5	5	5	15	100	Very Valid
5	No misconceptions or conceptual errors appear in explanations or questions.	5	4	4	13	86.6	Very Valid
B. Presentation and Learning Strategies							
6	The module structure (introduction, core activities, closing) is clear and systematic.	5	5	5	15	100	Very Valid
7	PjBL is implemented comprehensively and meaning fully.	5	4	4	13	86.6	Very Valid
8	The experiment (perforated bottle) is relevant and supports understanding of Dynamic Fluid concepts.	4	5	4	13	86.6	Very Valid
9	There are guiding and reflective questions that promote critical thinking and real-world connections.	5	4	4	13	86.6	Very Valid
10	The language used is easy for high school students to understand.	5	5	4	14	93.3	Very Valid
C. Graphics and Design							

11	The module layout is neat, attractive, and easy to follow.	4	5	4	13	86.6	Very Valid
12	Illustrations/images are relevant and support content comprehension.	4	5	4	13	86.6	Very Valid
13	The use of fonts, colors, and spacing supports readability.	4	4	4	12	80	Quite Valid
D. PjBL Learning Approach							
14	The “perforated bottle” project integrates science (physics), technology (Google Forms, video), and mathematics (flow rate/velocity calculations).	4	5	4	13	86.6	Very Valid
15	Students are given opportunities to design, test, analyze data, and reflect independently in groups.	5	4	4	13	86.6	Very Valid
16	The project develops 21st-century skills: critical thinking, creativity, collaboration, and independence.	5	4	4	13	86.6	Very Valid
E. Assessment							
17	Diagnostic, formative, and summative assessments are designed comprehensively.	5	5	4	14	93.3	Very Valid
18	Assessment instruments (LKPD, rubrics, reflective journals, summative tests) are aligned with learning objectives.	5	4	5	14	93.3	Very Valid
19	Authentic assessments (projects, presentations, reports) encourage deep understanding and application of concepts.	4	4	5	13	86.6	Very Valid
F. Relevance to Student Characteristics							
20	The material and activities align with the cognitive level of 11th-grade students.	5	5	5	15	100	Very Valid
21	The project can be completed with easily accessible materials at school/home.	4	5	5	14	93.3	Very Valid
22	The module promotes active participation and collaboration among students.	5	5	5	15	100	Very Valid

Based on the validation conducted by three experts covering physics content, instructional media, and language the PjBL based physics teaching module achieved a very high level of validity across all assessment components. The overall scores ranged from 80% to 100%, placing the module in the “very valid” category. This indicates that the module meets the expected standards in terms of content quality, presentation, design, and its alignment with students’ characteristics. For the content feasibility aspect, the module reached an average score of 93.3%, which is also classified as very valid. This result shows that the dynamic fluid topics such as flow rate, the continuity equation, and Bernoulli’s principle were presented accurately, scientifically, and in accordance with the Phase F Learning Outcomes of the Merdeka Curriculum. One indicator, however, received a slightly lower score of 80%, specifically related to scientific accuracy. This suggests that a few terms and conceptual explanations still need refinement to ensure greater consistency and precision. A comparison of the validity scores across all assessment aspects is presented in Figure 4.

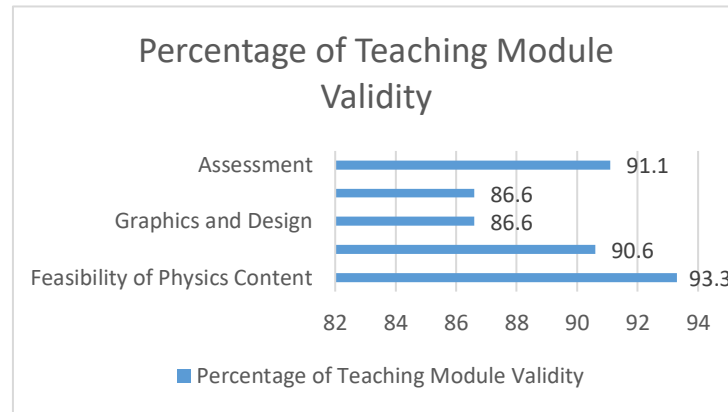


Figure 4. Average Validity Scores for Each Aspect of the PjBL-Based Physics Teaching Module

Based on the validation results for the presentation and learning strategy components, the teaching module was categorized as very valid. The structure consisting of the introduction, main activities, and closing was considered well organized and was found to apply the PjBL syntax effectively. The validators also highlighted that the “perforated bottle” experiment was appropriate for the dynamic fluid topic and succeeded in encouraging critical and creative thinking through its guiding questions and reflective tasks. In terms of graphics and design, the module received an average score of 86.6%, also classified as very valid. The layout, illustrations, and visual elements were viewed as clear and supportive of conceptual understanding. However, the readability indicator, particularly the combination of font style, color choices, and spacing, earned a score of 80%, indicating that slight adjustments are needed to improve reading comfort.

The PjBL component likewise obtained a very valid rating. This was evident from the way the “perforated bottle” project integrated elements of science, technology, and mathematics (STM). Through this activity, students were given space to design, test, and analyze their own data while developing key 21st-century skills such as collaboration, creativity, and independent learning. For the assessment aspect, the module recorded an average validity score of 91.1%, also in the very valid category. It included a complete set of diagnostic, formative, and summative assessments ranging from worksheets (LKPD) and project rubrics to reflective journals and final tests that were aligned with both the learning objectives and the nature of PjBL.

The relevance to student-characteristics aspect reached 97.8%, which falls into the very valid classification. This shows that the activities were well-matched to the cognitive level of eleventh-grade students, relied on materials that were easy to obtain, and successfully promoted active participation and collaboration throughout the project stages. Taken together, these findings indicate that the innovative dynamic fluid module is highly valid and suitable for use as a supplementary resource within the Merdeka Curriculum, particularly for strengthening students’ creative thinking and conceptual understanding. Following the validation stage, the module was tested on a limited scale through a One to One Evaluation to examine practicality, clarity of instructions, and readability. Three eleventh-grade students with high, medium, and low academic levels were selected to provide varied perspectives. Each student was asked to work through the module independently, review the steps in the “perforated bottle” project, and complete a response questionnaire.

The evaluation showed that all three students gave excellent ratings for the module’s appearance, language, content, and the real world relevance of the project. They reported that the material was easy to follow, helped them relate dynamic fluid concepts to everyday phenomena, and increased their interest in hands-on experimentation. Suggestions for improvement included adding more illustrations

to clarify the experimental steps and simplifying several physics terms. The students' summarized responses are presented in Table 6.

Table 6. Summary of One-to-One Evaluation Results

No.	Name	Percentage (%)	Category
1	FN	80.6	Practical
2	MA	97.3	Very Practical
3	KA	91.0	Very Practical
Average		89.63	Very Practical

Referring to the data in Table 6, the One to One Evaluation showed that the PjBL-based physics module on dynamic fluid concepts reached an average practicality score of 89.63%. This percentage places the module in the very practical category, which means that students found it readable, appealing, and easy to navigate. All three respondents gave consistently positive impressions two of them assessed the module as very practical, while one rated it as practical. Their feedback suggests that the project directions were straightforward, the visual layout supported the learning process, and the language level suited the cognitive stage of eleventh grade students. Given these outcomes, the module can move on to the Small Group Evaluation stage, with only minor adjustments needed based on the students' suggestions.

Building on the strong results from the One to One Evaluation, the study continued with the Small Group Evaluation to further examine how practical and easy-to-understand the module is when used in a collaborative learning situation. This stage also aimed to see whether the module remained attractive when implemented in a slightly wider learning environment. Six eleventh-grade students participated and were divided into two groups. Each group explored the module, carried out the "perforated bottle" project which applied the concepts of flow rate, the continuity equation, and Bernoulli's principle and filled out a response questionnaire. The evaluation covered several aspects, including readability, clarity of instructions, project relevance, visual quality, and usefulness for grasping physics concepts. The results of this phase are summarized in Table 7.

Table 7. Summary of Small Group Evaluation Results

No.	Name	Percentage (%)	Category
1	JA	90.3	Very Practical
2	M	88.6	Very Practical
3	MZF	95.0	Very Practical
4	NT	91.6	Very Practical
5	MSS	93.3	Very Practical
6	MMN	94.2	Very Practical
7	RDS	91.6	Very Practical
8	ZAH	86.6	Very Practical
9	LSK	95.0	Very Practical
Average		91.8	Very Practical

Table 7 indicates that the Small Group Evaluation produced an average score of 91.8%, placing the module in the very practical category. This result strengthens the conclusion that the PjBL based physics module on dynamic fluid concepts has excellent practicality. The students involved expressed that the module was simple to navigate, used clear and communicative language, offered engaging visuals, and provided project activities that were relevant and motivating throughout the learning process. When the

expert validation and the user feedback from both evaluation stages One to One and Small Group are viewed together, it becomes evident that the innovative dynamic fluid module demonstrates very high levels of validity and practicality. These outcomes show that the module is ready to be implemented as a supplementary teaching resource within the Merdeka Curriculum, particularly to support students' conceptual mastery and foster their creative thinking skills. A comparison of practicality results from the two evaluation stages can be seen in Figure 5.

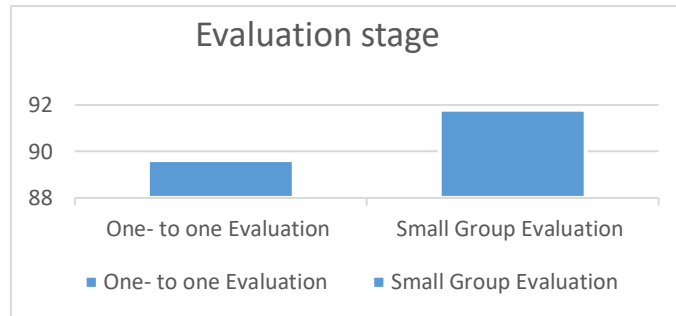


Figure 5. Comparison of Teaching Module Practicality Based on User Evaluations

Figure 5 shows that the practicality scores obtained from users 89.63% in the One to One Evaluation and 91.8% in the Small Group Evaluation both fall within the very practical category. The higher percentage in the smallgroup setting suggests that students find the module even more accessible and easier to apply when learning collaboratively. These results reflect the two essential development criteria highlighted by Aldilla (2024) a valid product and one that can be used effectively without substantial revision. The expert validation strengthens this conclusion. Their assessment confirmed that the module fulfills all aspects of feasibility, including material accuracy, clarity of presentation, linguistic appropriateness, and instructional design. This pattern is consistent with Aldilla (2024) claim that PjBL-oriented learning resources typically score highly in validity because they encourage authentic scientific engagement and contextual learning experiences. The alignment of dynamic fluid concepts with Phase F Learning Outcomes further strengthens the scientific coherence of the material, in accordance with the view of Yulkifli et al. (2022) that meaningful physics learning must relate conceptual content to everyday contexts.

The quantitative results show that the developed module achieved high levels of validity and practicality across all evaluation stages. Expert validation results ranged from 80% to 100%, indicating that the module met the “very valid” criteria in terms of content feasibility, presentation, language, and graphic design. In addition, the practicality scores obtained from the One-to-One Evaluation (89.63%) and the Small Group Evaluation (91.8%) demonstrate that the module is categorized as very practical when implemented with students. The consistent use of PjBL syntax from the formulation of essential questions through the reflective stage also shows that the module applies the model in line with the Merdeka Curriculum guidelines. This echoes the findings of Zhafira Nurazizah et. al (2025) who reported that contextual project activities improve students' reflective and creative capacities through collaborative investigation. Meanwhile, the suggestions from validators regarding font readability and visual organization are aligned with Hakim & Hidayani (2021), who emphasize that supportive graphic design enhances students' understanding of abstract physics concepts. Student feedback across both evaluation stages further confirms the module's practicality. Learners described the material as easy to use, clear in communication, and suitable for independent study, an outcome that corresponds with Rediani, (2024), who found that project-based resources encourage autonomy and strengthen scientific reasoning. Taken together, these results reinforce the conclusions reached by Ramadhani et al. (2024), whose meta-analysis identifies PjBL as a consistent driver of improved critical and creative

thinking. Additionally, the integration of science, technology, and mathematics within the “perforated bottle” project provides students with reflective and meaningful learning opportunities that align with deep learning principles.

4. CONCLUSION

This study aimed to develop a PjBL-based physics teaching module with a deep learning approach on dynamic fluid concepts, and the findings indicate that this objective has been successfully achieved. Validation by three expert validators resulted in scores ranging from 80% to 100%, classified as *very valid*, demonstrating that the module meets the expected criteria for content feasibility, presentation, language, graphic design, and alignment with student characteristics as outlined in the introduction. The practicality results from both stages the One to One Evaluation (89.63%) and the Small Group Evaluation (91.8%) demonstrate that the module is straightforward to use, visually engaging, and supportive of students’ understanding of flow rate, the continuity equation, and Bernoulli’s principle through the project tasks provided. Taken as a whole, these findings show a clear consistency between the development goals set out in the introduction and the outcomes revealed in the results and discussion. With its very high validity and practicality, the PjBL-based module supported by a deep learning approach is considered appropriate for use as a supplementary learning resource within the Merdeka Curriculum. Moving forward, the module can be expanded into the disseminate phase to examine its broader impact on conceptual understanding and creative thinking, and it may also be adapted for other physics topics that benefit from project-based and deep learning oriented instruction.

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