

Development of E-Modules Based on Problem-Based Learning to Improve Students' Problem-Solving Skills in Static Fluid Material

Ardian*, Erniwati, and Hunaidah M.

Physics Education Study Program, Faculty of Teacher Training and Education,
Halu Oleo University, Kendari, Indonesia

*ardian03pfis@gmail.com

Article Info	Abstract
Article history: Received: April 20, 2026 Accepted: May 23, 2026 Published: July 1, 2026 Keywords: E-module Problem-based learning Problem-solving skills Static fluids This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License © 2026 Berkala ilmiah Pendidikan Fisika	This study aimed to develop an E-module based on problem-based learning on static fluid material to improve the problem-solving abilities of grade XI students. The study used a research and development (R&D) approach with the 4D model consisting of define, design, develop, and disseminate stages. The participants were 40 grade XI students from a public senior high school in Indonesia and two physics teachers involved in assessing the practicality of the E-module. The instruments included validation sheets, practicality questionnaires, and pretest-posttest tests to measure the improvement of students' problem-solving abilities. Validation by three experts showed a validity score of 92.64% (very valid). Student practicality responses reached 91.76% and 92.41%, while teacher responses reached 94.86%, all categorized as very practical. The effectiveness test showed N-gain scores of 0.76 in class XI.B, 0.77 in class XI.C, and 0.77 overall, which were categorized as high based on Hake's classification, indicating that the E-module effectively improved students' problem-solving abilities. The novelty of this study lies in integrating structured problem-based learning activities into a digital E-module for static fluid learning. Overall, the developed E-module is feasible and effective as a digital teaching material to support active, guided, and meaningful physics learning. To cite this article: Ardian, A., Erniwati, E., & M, H. (2026). Development of e-modules based on problem-based learning to improve students' problem-solving skills in static fluid material. <i>Berkala Ilmiah Pendidikan Fisika</i>, 14(2), 233-252.

INTRODUCTION

The developments of the 21st century contribute to changes in educational dynamics, including the advancement of technology and science in the learning process ([Kurniati et al., 2021](#)). The advancement of science and technology is expected to foster students' critical thinking, creativity, communication, collaboration, and problem-solving abilities ([Pane et al., 2021](#)). Problem-solving skills involve students' ability to understand problems, formulate solution strategies, implement solutions, and evaluate the results obtained. In physics learning, these skills are particularly important because many physics concepts, including static fluids, require analytical thinking and the application of concepts to contextual phenomena encountered in everyday life.

Findings from several studies, including those by [Bura et al. \(2024\)](#), [Estianinur et al. \(2020\)](#), and [Ringo et al. \(2019\)](#), indicate that students' problem-solving abilities in static fluid material remain relatively low. [Ringo et al. \(2019\)](#) found that only 31% of students were categorized as proficient, while 69% were still at the novice level. [Estianinur et al. \(2020\)](#) also reported that 86% of students were classified in the novice category.

Meanwhile, [Bura et al. \(2024\)](#) revealed that students experienced difficulties, particularly in reviewing and re-verifying solutions, with an achievement percentage of only 38.09%. These findings indicate that students still experience difficulties in connecting physics concepts with problem situations, selecting appropriate solution strategies, and evaluating the correctness of their answers.

Similar conditions were identified among grade XI students at one public senior high school in Indonesia, where students' problem-solving abilities in static fluid material were still categorized as low based on interviews with physics teachers and analysis of students' answers. Most students were only able to identify known variables and apply formulas directly without explaining conceptual relationships or rechecking their final answers. According to [Opilah et al. \(2022\)](#), problem-solving ability includes identifying problems, relating them to physics concepts, planning solutions, implementing solution strategies, and evaluating results. However, students' answers generally fulfilled only several indicators and did not comprehensively demonstrate all stages of problem-solving ability. This condition may be influenced by teacher-centered learning practices, limited opportunities for students to investigate contextual problems independently, and the lack of interactive teaching materials that support active learning.

Integrating the problem-based learning model into the learning process is considered effective in improving students' problem-solving abilities ([Selviani et al., 2024](#)). By presenting contextual problems, this model encourages students to think critically, analyze information, and construct solutions independently ([Kardono, 2023](#)). In this model, students actively engage in questioning, investigating, discussing, and presenting solutions, while teachers act as facilitators ([Putri et al., 2023](#)). The Problem-Based Learning model consists of five stages: orienting students to problems, organizing students for learning, guiding investigations, developing and presenting work results, and analyzing and evaluating the problem-solving process ([Purnomo et al., 2022](#)).

The integration of problem-based learning into teaching materials is believed to improve learning effectiveness in developing problem-solving abilities ([Sihombing & Armanto, 2024](#)). Teaching materials are systematically designed resources that help students understand concepts more effectively while supporting teachers in organizing structured learning processes ([Marsa & Desnita, 2020](#)). In practice, schools commonly use printed textbooks, e-books, and modules from the Ministry of Education and Culture, as well as E-modules, LKS, and LKPD available online ([Faidar et al., 2023](#)). In practice, schools commonly use printed textbooks, e-books, and modules from the Ministry of Education and Culture, as well as E-modules, LKS, and LKPD available online. However, these teaching materials are not always adapted to students' learning needs and characteristics. This condition is influenced by teachers' limited ability to develop innovative and technology-based teaching materials independently ([Darniyanti et al., 2023](#)).

The development of digital teaching materials such as E-modules offers an alternative solution because they can integrate interactive features, including videos, animations, hyperlinks, audio, and virtual laboratories, which are difficult to implement in conventional printed materials ([Fitriyani et al., 2021](#)). E-modules also provide flexibility for students to learn independently according to their learning pace and abilities ([Wahrini & Makmur, 2023](#)). As technology-based teaching materials, E-modules are systematically arranged with clear learning stages to support students in achieving learning objectives more effectively ([Putri et al., 2022](#)).

E-modules also provide flexibility for students to learn independently according to their learning pace and abilities. Several previous studies have developed Problem-Based Learning-based E-modules and reported positive results in terms of validity, practicality, and effectiveness ([Butar & Panggabean \(2022\)](#); [Gita et al., \(2022\)](#); [Panggabean & Sembiring \(2022\)](#); [Wiendari et al., \(2023\)](#)). Nevertheless, previous studies generally focused on learning outcomes and conceptual understanding, while limited studies

specifically emphasized the improvement of problem-solving abilities in static fluid material through structured problem orientation activities integrated into all learning stages.

Another limitation of previous studies is that the use of contextual video-based problem orientation in every subtopic of static fluid learning has not been implemented comprehensively. Therefore, this study develops an E-module that integrates problem-based learning stages with contextual videos in each problem orientation activity to support students' understanding, engagement, and problem-solving processes in static fluid learning. Based on these considerations, this study, entitled "Development of E-Modules Based on Problem-Based Learning to Improve Students' Problem-Solving Skills in Static Fluid Material," was conducted to develop a digital teaching material that supports independent, active, and meaningful learning while improving students' problem-solving abilities.

METHODS

This research employed a research and development (R&D) method focused on planning, development, and evaluation processes. The main objective was to develop a problem-based learning E-module on static fluid material to improve the problem-solving abilities of grade XI students. The development procedure adopted the 4D model proposed by [Thiagarajan et al. \(1974\)](#), consisting of the define, design, develop, and disseminate stages. At the define stage, curriculum analysis, student characteristics analysis, concept analysis, and problem analysis were conducted to identify learning needs and students' difficulties in static fluid materials. The design stage involved preparing the E-module structure, learning activities, instruments, and media elements. The development stage included expert validation, product revision, and limited trials to evaluate the validity, practicality, and effectiveness of the E-module. The dissemination stage was conducted through the limited distribution of the final E-module to physics teachers and students for learning use.

The research was conducted from November 2024 until completion at the Physics Education Department Laboratory, Halu Oleo University. The implementation of the E-module in schools was conducted in three meetings for each class during static fluid learning activities. The product trial involved grade XI students from one public senior high school in Indonesia. The subjects consisted of 40 students from two classes and two physics teachers in the even semester of the 2024/2025 academic year. The sampling technique used was purposive sampling, in which the classes were selected based on recommendations from the physics teacher by considering students' learning characteristics and the suitability of the static fluid learning schedule.

Data collection in this study used three instruments, namely expert validation sheets to determine the validity of the E-module, response questionnaires from students and teachers to evaluate practicality, and written pretest-posttest tests to measure effectiveness. The validation instruments were assessed by three expert validators, consisting of lecturers and physics education experts, based on construction feasibility, content feasibility, presentation feasibility, and language feasibility aspects before being used in the research.

The problem-solving test items were developed based on problem-solving ability indicators adapted from [Opilah et al. \(2022\)](#), including identifying problems, relating problems to physics concepts, planning solution strategies, implementing solutions, and evaluating the obtained results. The data from the validation sheets were analyzed by calculating the average score of each indicator, and the results were categorized according to the validity criteria proposed by [Pixyoriza et al. \(2022\)](#), as presented in Table 1.

Table 1 Validity level criteria

Percentage (%)	Validity Criteria
85-100	Very Valid
70-84	Valid
55-69	Quite Valid
50-54	Less Valid

Percentage (%)	Validity Criteria
0-49	Invalid

The questionnaire responses from students and teachers were analyzed by calculating the average score for each aspect and classifying the results based on the practicality criteria proposed by [Pixyoriza et al., \(2022\)](#), as presented in Table 2.

Table 2 Practicality level criteria

Percentage (%)	Practical Criteria
85-100	Very Practical
70-84	Practical
55-69	Quite Practical
50-54	Less Practical
0-49	Not Practical

The analysis of students' pretest and posttest scores used the N-gain formula proposed by [Hake \(2002\)](#). The effectiveness interpretation categories in this study consisted of high, medium, and low categories based on Hake's classification criteria, as presented in Table 3.

Table 3 Interpretation of N-gain

N-gain	Criteria
$(g) \geq 0.7$	High
$0.7 > (g) \geq 0.3$	Medium
$(g) < 0.3$	Low

RESULTS AND DISCUSSION

The findings of this study are in the form of a physics learning E-module product based on the problem-based learning model on static fluid material for Class XI Phase F. The explanation of the development results is arranged based on each stage of the 4D model.

Define Stage

The research results obtained at this stage include facts, data, and a series of needs in the research process related to the development of E-modules during the physics learning process at SMA Negeri 5 Baubau. This stage consists of several analyses, including:

1. Initial Analysis

The initial analysis acquired by interviews with physics teachers at SMA Negeri 5 Baubau indicates that students' problem-solving skills are below the expected standard. Based on classroom observations and teacher interviews, students generally experienced difficulties in interpreting contextual physics problems, identifying relevant concepts, and determining appropriate solution strategies. Most students tended to directly apply formulas without first analyzing the problem situation conceptually. In addition, students rarely re-evaluated their final answers, indicating that problem-solving activities had not yet been carried out systematically in accordance with the stages proposed by Heller and Heller ([Viyanti et al., 2025](#)).

This limitation is not only influenced by internal student factors but is also closely related to external factors, particularly the availability and use of learning resources in the instructional process. Currently, learning activities are still dominated by printed textbooks as the primary source, while available digital resources are largely limited to static PDF e-books. The available teaching materials mainly contain summaries and routine exercises and have not yet facilitated interactive learning activities capable of training higher-order thinking and problem-solving skills. During classroom learning, students were generally passive and relied heavily on teacher explanations, resulting in limited opportunities for investigation and collaborative discussion activities. In line with this condition, [Febrilla et al., \(2024\)](#) reported that school teaching materials are

still predominantly print-based, have not been integrated with digital technology, and are not supported by learning models that promote student independence. As a result, the learning process has not yet been optimal in achieving learning objectives, particularly in enhancing students' problem-solving skills. Therefore, there is a need to develop more interactive, innovative, and technology-based teaching materials to support a more effective and student-centered learning process.

2. Student Analysis

The initial analysis of students at SMA Negeri 5 Baubau indicates that the majority are between 16 and 17 years old, putting them in the formal operational stage in accordance with Jean Piaget's theory of cognitive development. Although students are theoretically capable of abstract and logical thinking, the findings showed that they still experienced difficulties in connecting theoretical concepts with contextual phenomena related to the static fluid material ([Adeduyigbe & Okeke, 2025](#)). Various studies have shown that students' conceptual understanding of static fluid material remains relatively low and is often accompanied by misconceptions, especially regarding hydrostatic pressure, buoyancy, and Pascal's law ([Irawan et al., 2026](#)). These misconceptions hinder students' ability to connect concepts with contextual situations and limit the development of higher-order thinking skills ([Busyairi & Zuhdi, 2024](#)).

Furthermore, students tend to rely on memorizing formulas without fully understanding their conceptual meaning, which leads to difficulties when they are faced with contextual problems. The interview results also indicated that students often focused only on obtaining numerical answers rather than understanding the reasoning process used to solve the problems. This condition caused students to experience difficulties when solving problems presented in different contexts from examples previously given by the teacher. This condition aligns with findings in physics education research indicating that students often focus more on mathematical manipulation than on conceptual understanding, resulting in shallow comprehension and poor problem-solving performance ([Dockett et al., 2015](#)). Consequently, students' problem-solving skills remain low, as they are not yet accustomed to applying systematic problem-solving strategies.

On the other hand, students' learning characteristics show a preference for group discussions, highlighting the importance of social interaction in the learning process, as emphasized in the social constructivist perspective of Lev Vygotsky ([Chand, 2023](#)). In addition, students exhibit diverse learning styles, with a tendency toward visual learning, hands-on experiments, and interactive activities. These findings indicate the need for instructional materials that integrate multimedia features, contextual investigations, and collaborative problem-solving activities to support deeper conceptual understanding and active student engagement during learning.

3. Material Analysis

The material analysis is conducted to ensure the alignment of the E-module content with the learning outcomes and instructional objectives of the Merdeka Curriculum implemented at SMA Negeri 5 Baubau, as well as the competencies outlined in BSKAP Decree No. 008/H/KR/2022 issued by the Ministry of Education, Culture, Research, and Technology. This alignment reflects the principle of constructive alignment, which emphasizes the systematic coherence among learning outcomes, learning materials, and instructional objectives to ensure a structured and goal-directed learning process ([Pereira et al., 2024](#)).

The selection of static fluid content is based on findings indicating that students' problem-solving abilities in this topic remain low, thereby requiring more structured learning materials to support their improvement. The material developed in this study was limited to hydrostatic pressure, Pascal's law, Archimedes' principle, surface tension, capillarity, viscosity, and Stokes' law. Dynamic fluid material was not included

to maintain a more focused and in-depth development process. This study was also limited to the development and limited implementation of the E-module for class XI Phase F students at SMA Negeri 5 Baubau, with effectiveness measured specifically through students' problem-solving abilities. Systematically designed learning materials have been shown to enhance students' problem-solving abilities in physics learning ([Sitompul et al., 2025](#)). In addition, digital learning materials such as E-modules support more independent and well-directed learning, enhance students' motivation, and are relevant to learners' needs ([Apriliani & Riyanto, 2025](#)). Furthermore, the integration of digital and interactive learning resources supports more student-centered learning by improving accessibility, flexibility, and student engagement during the learning process.

4. Concept Analysis

The findings of the analysis of the concept of static fluid material selected by the researcher include three main areas, namely the basic concept of static fluid, the laws that apply in static fluid, and phenomena related to static fluid. In the basic concept section, the material includes the definition of static fluid, pressure, hydrostatic pressure, and absolute pressure. In the aspect of static fluid law, the laws of hydrostatics, Pascal's law, and also Archimedes' law are discussed. Meanwhile, the phenomena of static fluid analyzed include surface tension, capillary phenomena, viscosity, and Stokes' law. These concepts were systematically organized from fundamental concepts to contextual applications and were integrated into problem-based learning activities through contextual phenomena such as hydraulic systems, floating objects, water reservoirs, and capillary events encountered in everyday life.

5. Learning Objective Specifications

The results of the learning objective specifications are derived from the learning outcomes of the Independent Curriculum in Physics Phase F. The learning objectives are designed to integrate three main competency domains, namely knowledge, skills, and attitudes, which are achieved through students' active involvement in learning activities. This structure reflects the principle of constructive alignment, in which instructional activities, learning outcomes, and assessment are systematically connected to ensure meaningful learning ([Lefera & Swart, 2024](#)).

Furthermore, the formulation of learning objectives serves as measurable indicators of student achievement, allowing the extent of learning outcomes to be clearly identified. Therefore, learning objectives must be formulated in a specific, measurable, and observable manner, consistent with competency-based curriculum design principles in education ([Albina & Pratama, 2025](#)). In this study, the learning objectives were also aligned with the stages of problem-based learning and problem-solving indicators, enabling students not only to understand concepts theoretically but also to apply them systematically in solving contextual static fluid problems.

Overall, the results of the define stage indicate that the development of a problem-based learning-based E-module on static fluid material is relevant and necessary to address students' low problem-solving abilities ([Yuliani et al., 2025](#)). The analysis showed that students still experienced difficulties in connecting concepts with contextual phenomena, while existing teaching materials had not optimally supported interactive and student-centered learning ([Kurniawan et al., 2023](#); [Prastiwi et al., 2018](#)). The findings demonstrated a strong alignment among curriculum demands, learning objectives, instructional materials, and students' characteristics, providing a clear conceptual and empirical foundation for the development of the E-module integrated with problem-based learning activities and structured problem-solving exercises. In addition, the analysis revealed a strong alignment among curriculum demands, learning objectives, instructional materials, and students' characteristics, indicating that the development process has a strong conceptual and contextual foundation to support effective and meaningful learning ([Syathroh et al., 2024](#)).

The consistency of these findings demonstrates that the identified learning problems, students' needs, and instructional objectives are systematically interconnected and aligned with actual classroom conditions, thereby appropriately supporting the continuation of the design and development stages of the problem-based learning-based E-module on static fluid material ([Wiendari et al., 2023](#)).

Design Stage

At this point, the outcomes include research instruments, learning media, format, content, and the initial design of the E-module, which were developed in an integrated manner. The instruments consist of validation sheets, questionnaires for teachers and students, and pretest–posttest tests designed to measure students' improvement in problem-solving skills. The development of these instruments follows systematic and valid assessment principles in educational research ([Hutasuhut & Albina, 2025](#)).

The learning media were designed based on the problem-based learning approach, which positions authentic problems as the starting point of learning and has been proven effective in improving problem-solving and higher-order cognitive abilities ([Al-Farisi et al., 2023](#)). In this study, the implementation of problem-based learning was integrated directly into the structure of the E-module through several learning stages, namely problem orientation, problem identification, group discussion, investigation activities, presentation of findings, and evaluation of solutions. Each learning activity began with contextual static fluid phenomena encountered in everyday life, such as hydraulic systems, floating objects, hydrostatic pressure in water reservoirs, and capillary events, which were used as triggers for investigation and discussion activities.

To support this approach, the media incorporate visual elements such as images, videos, and animations relevant to static fluid concepts, consistent with multimedia learning research showing that visual and interactive materials improve conceptual understanding and student engagement ([Aswara et al., 2021](#)). The E-module also integrated interactive features such as embedded learning videos, hyperlinks, navigation buttons, QR-code-based multimedia access, contextual exercises, and independent evaluation activities. These features were designed to facilitate students in independently exploring learning materials, visualizing abstract concepts, and actively engaging in problem-solving activities during the learning process.

Additionally, the development of the e-module is grounded in established instructional design principles, emphasizing structured content organization, interactive learning experiences, and the promotion of learner autonomy through clearly defined learning objectives, practice opportunities, feedback mechanisms, and flexible navigation ([Najuah et al., 2020](#)). The organization of the E-module content was systematically arranged from conceptual understanding to contextual application activities. Students were guided to identify problems, formulate solution strategies, apply relevant concepts, and evaluate their final answers through structured problem-solving exercises integrated into each learning section. Considering these principles, the E-module format was created in compliance with the Ministry of Education and Culture guideline No. 38 of 2017 and adapted from the framework proposed by [Nilyani and Ratnawulan \(2023\)](#), resulting in a systematic and user-friendly structure for learning.

The content sources include textbooks, modules, E-modules, and physics teaching materials relevant to static fluid topics. These materials were then processed using Canva and Flip PDF Professional to produce an E-module that integrates text, images, videos, and other visual components in a coherent and structured learning package. The use of Flip PDF Professional also enabled the integration of interactive multimedia components and flexible navigation features, allowing students to access videos, contextual phenomena, and problem-solving activities more efficiently during both independent and classroom learning activities.

Overall, the design stage successfully produced an initial prototype of the problem-based learning-based E-module that was aligned with curriculum demands, students' learning needs, and the characteristics of static fluid material. The developed E-module integrated problem-based learning syntax, contextual problem-solving activities, interactive multimedia features, and flexible navigation into a structured digital learning resource. These components collectively support interactive, student-centered, and meaningful physics learning by facilitating conceptual understanding, independent learning, and systematic problem-solving activities (Safitri et al., 2025). Therefore, the resulting prototype was considered suitable for further validation and development processes (Antonius et al., 2022).

Develop Stage

The result of this stage is the creation of a physics learning E-module based on the problem-based learning model on static fluid material for grade XI students in the even semester. This E-module has previously been validated by a team of experts who assessed its feasibility based on four aspects, namely construction, content, presentation, and language, before being used in learning by students. This process is important to ensure the quality and alignment with educational standards, as well as the feasibility and effectiveness of instructional materials prior to their implementation in the learning process (Fuentes & DPA, 2025). The outcomes are presented in Table 4.

Table 4 Validation results of physics learning E-modules based on problem-based learning models on static fluid material from the validator team

No.	Assessment Aspects	Σx	$\bar{P}$ (%)	Criteria
1.	Construction Feasibility Aspects	114.67	91.73	Very Valid
2.	Content Feasibility Aspects	163.3	93.33	Very Valid
3.	Presentation Feasibility Aspects	61.67	94.87	Very Valid
4.	Language Feasibility Aspects	58.67	90.26	Very Valid
Σx for All Aspects		398.33		
Σxi for All Aspects		430		
$\bar{P}$ for All Aspects		92.64%		
Validity Criteria for All Aspects		Very Valid		

Information: Σx = Number of answer values obtained from expert validators; Σxi = Maximum score; $\bar{P}$ = Percentage of validity level

Referring to Table 4, the E-module is considered very valid with a validity percentage of 92.64%. Validators provided assessments and recommendations prior to implementation. The revised version can be accessed at <https://online.flipbuilder.com/tknuz/elqd/> or by scanning the QR code in Figure 1.



Figure 1 QR code for accessing the physics learning E-module based on the problem-based learning model on static fluid material

Disseminate Stage

Before entering the disseminate stage, the researcher first conducted a pretest involving 40 students from class XI.B and XI.C to identify students' initial problem-solving abilities on static fluid material before using the developed E-module. Furthermore, a limited trial of the E-module was carried out at SMA Negeri 5 Baubau involving 20 students in each class for five learning meetings over three weeks. The implementation of the E-module during the trial process integrated problem-based learning activities through contextual problems, group discussions, investigation activities, practice questions, videos, and evaluation tasks to support students' active involvement during learning.

After the implementation process, the E-module was evaluated by students and physics teachers to determine its level of practicality and effectiveness in supporting learning activities. The results of student response analysis toward the E-module are presented in Tables 5 and 6.

Table 5 Results of analysis of class XI.B students' responses to the physics learning E-module based on the problem-based learning model on static fluid material

No.	Assessment Aspects	Σ J.R.	P (%)	Criteria
1.	Display Aspect	38	95	Very Practical
2.	Presentation Aspects	40.55	90.11	Very Practical
3.	Practical Aspects	42.45	91.89	Very Practical
4.	Effectiveness Aspect	18.05	90.3	Very Practical
5.	Benefits Aspect	31.8	90.86	Very Practical
Σ J.R. for All Aspects		169.75		
Σ N. I. for All Aspects		185		
Percentage of Practicality		91.76%		
Criteria for All Aspects		Very Practical		

Information: Σ J.R. = Total value of respondents' answers; P = Percentage of respondents' answers; Σ N.I. = Ideal value sum of respondents' answers

Table 6 Results of analysis of class XI.C students' responses to the physics learning E-module based on the problem-based learning model on static fluid material

No.	Assessment Aspects	Σ J.R.	P (%)	Criteria
1.	Display Aspect	37.25	93.13	Very Practical
2.	Presentation Aspects	42.25	93.89	Very Practical
3.	Practical Aspects	41.75	92.78	Very Practical
4.	Effectiveness Aspect	18.25	91.3	Very Practical
5.	Benefits Aspect	31.45	89.86	Very Practical
Σ J.R. for All Aspects		170.95		
Σ N. I. for All Aspects		185		
Percentage of Practicality		92.41%		
Criteria for All Aspects		Very Practical		

Information: Σ J.R. = Total value of respondents' answers; P= Percentage of respondents' answers; Σ N.I. = Ideal value sum of respondents' answers

Meanwhile, the analysis results of teacher responses to the E-module are shown in Table 7.

Table 7 Results of teacher response analysis on physics learning E-module based on problem-based learning model on static fluid material

No.	Assessment Aspects	Σ J.R.	P (%)	Criteria
1.	Display Aspect	38	95	Very Practical
2.	Presentation Aspects	42.5	94.44	Very Practical
3.	Practical Aspects	43.5	96.67	Very Practical
4.	Effectiveness Aspect	17.5	87.5	Very Practical
5.	Benefits Aspect	34	97.14	Very Practical
Σ J.R. for All Aspects		175.5		
Σ N. I. for All Aspects		185		

No.	Assessment Aspects	Σ J.R.	P (%)	Criteria
	Percentage of Practicality		94.86%	
	Criteria for All Aspects		Very Practical	

Information: Σ J.R. = Total Value of respondents' answers; P = Percentage of respondents' answers; Σ N.I. = Ideal value sum of respondents' answers

The positive responses from both students and teachers indicate that the developed E-module was considered attractive, easy to use, and effective in supporting both independent and guided learning activities.

The data obtained from the three tables confirm that the developed E-module meets the criteria of being very practical according to the assessment results. This is indicated by the percentage of practicality of 91.76% from class XI.B students, 92.41% from class XI.C students, and 94.86% from physics teachers at SMA Negeri 5 Baubau.

After students and teachers completed the practicality assessment, the researcher conducted a posttest to determine students' problem-solving abilities after using the E-module. The effectiveness of the E-module was assessed by comparing students' problem-solving abilities before and after implementation using pretest and posttest results. The level of improvement was measured using the N-gain score, which is widely used to evaluate learning effectiveness (Hake, 2002). The N-gain values for each class are presented in Tables 8, 9, and 10.

Table 8 Results of improving problem-solving skills of class XI.B students on static fluid material

Variable	Pretest	Posttest
Highest Score	38.4	99
Lowest Score	13.3	71
Average	21.8	81.59
N-gain		0.76
Criteria		High

Table 9 Results of improving problem-solving skills of class XI.C students on static fluid material

Variable	Pretest	Posttest
Highest Score	34.5	98
Lowest Score	13.5	75.4
Average	21.95	82.27
N-gain		0.77
Criteria		High

Table 10 Results of improving students' overall problem-solving abilities

Variable	Pretest	Posttest
Highest Score	38.4	99
Lowest Score	13.3	71
Average	21.85	82.07
N-gain		0.77
Criteria		High

As shown in the analyses across Tables 8, 9, and 10, the effectiveness of the E-module in physics instruction is indicated by N-gain scores of 0.76, 0.77, and 0.77, all of which are categorized as high. These findings indicate that the learning activities integrated into the E-module were able to support students in understanding static fluid concepts and solving contextual physics problems more systematically and effectively.

The Validity of a Physics E-Module Based on the Problem-Based Learning Model on Static Fluid Material

The validity of the E-module refers to the extent to which the developed product accurately represents learning objectives, content relevance, and appropriate presentation in accordance with learners' characteristics. Therefore, expert judgment is required to ensure that the E-module meets the feasibility standards of instructional materials prior to its implementation in the learning process ([Suparni & Nasution, 2025](#)).

The validation process in this study was conducted based on four essential aspects: construct appropriateness, content accuracy, presentation quality, and clarity of language. These aspects represent key components in instructional material development, including alignment with learning objectives, conceptual correctness, systematic presentation, and comprehensibility for learners ([Kurniawan & Syafriani, 2021](#)). The validation process employed 86 assessment items distributed across the four aspects. The evaluation was carried out by three expert validators with expertise in instructional development and physics education at a state university in Indonesia, ensuring the credibility of the validation results.

The results of this study indicate that the construct aspect obtained a percentage of 91.73% and was categorized as very valid. This result indicates that the E-module had a consistent layout, readable typography, relevant illustrations, clear instructions, and easy navigation, which supported the usability of the E-module in learning activities. This finding is consistent with [Ariawan et al. \(2022\)](#), who stated that the alignment of design and usability components contributes to the construct validity of instructional materials. Furthermore, the content aspect obtained a percentage of 93.33% and was categorized as very valid. This finding indicates that the material in the E-module was aligned with the learning outcomes and learning objectives; presented accurate concepts, illustrations, and problem-solving questions; and integrated the stages of the problem-based learning model through contextual learning activities. These aspects contributed to the relevance and accuracy of the material presented in the E-module, consistent with [Fauziah et al. \(2023\)](#), who stated that the alignment of material content and instructional components contributes to the content validity of instructional materials.

In the presentation aspect, the highest percentage of 94.87% was obtained with a very valid category. This result indicates that the E-module had a systematic and sequential presentation, supported by complete presentation components, clear instructions, practice and evaluation questions, as well as interactive learning activities that encouraged students' involvement during the learning process. These aspects contributed to the presentation feasibility of the E-module, consistent with [Fauziah et al. \(2023\)](#) and [Ariyanto et al. \(2023\)](#), who stated that the completeness and organization of presentation components contribute to the feasibility of instructional materials. Meanwhile, the language aspect obtained a percentage of 90.26% and was categorized as very valid. This result indicates that the language used in the E-module was clear, communicative, systematic, and appropriate to students' level of development, supported by consistent terms and symbols, effective sentence structures, and coherent learning explanations. These aspects contributed to the language feasibility of the E-module, consistent with [Fauzi et al. \(2025\)](#), who stated that the clarity and consistency of language components contribute to language feasibility in instructional materials. Overall, the E-module obtained a total score of 398.33 out of a maximum score of 430, which corresponds to a validity percentage of 92.64%. Referring to the validity score interpretation criteria presented in Table 1, a percentage above 85% is categorized as "Very Valid." This means that the developed E-module has a high level of feasibility and is appropriate for use in the learning process ([Nisa et al., 2020](#)).

In addition to the quantitative assessment, the validators also provided constructive feedback in the form of suggestions and comments to improve the developed E-module ([Ramadhani & Lubis, 2025](#)). The input from the experts was used as a reference to revise

several components of the product, including the use of more credible sources, improvements in writing and grammar, consistency of symbols and citations; clarity of learning instructions, refinement of visual design and layout, improvement of video quality, and the adjustment of contextual problems and material applications to make them more relevant to learners' daily experiences. This revision process reflects the application of formative evaluation principles in instructional design, which emphasize continuous improvement to optimize product quality ([Syathroh et al., 2024](#)). Through these revisions, the overall quality and feasibility of the E-module as a learning resource were further enhanced.

After undergoing improvements based on expert recommendations, the E-module was considered valid and appropriate for implementation in physics learning. The high validity results indicate that the developed E-module successfully integrated problem-based learning syntax, interactive multimedia features, and structured problem-solving activities into a digital learning resource. This integration reflects the novelty of the study, in which the E-module combines contextual problems, interactive multimedia, and systematic problem-solving activities on static fluid material in accordance with the Merdeka Curriculum. Unlike previous studies that mainly focused on digital teaching materials or conceptual understanding, this study emphasizes the integration of problem-based learning syntax and interactive learning features to support students' problem-solving skills through both independent and guided learning activities. These findings are in line with studies by [Pixyoriza et al. \(2022\)](#) and [Slamet \(2022\)](#), which reported that instructional materials with high validity levels tend to demonstrate strong feasibility for use in the learning process.

The Practicality of a Physics E-Module Based on the Problem-Based Learning Model on Static Fluid Material

The practicality of the E-module was determined based on responses from students and teachers as end users. In educational product development, practicality refers to the extent to which a product is easy to use, understandable, and applicable in real learning situations. Practicality serves as an important indicator for determining whether a developed product can function effectively during implementation ([Ningsih et al., 2025](#)). Therefore, the practicality assessment in this study involved students and teachers as users of the developed E-module.

Student responses serve as the primary indicator of the E-module's practicality because they directly reflect users' experiences during the learning process. Learners' perceptions of ease of use, attractiveness, and usefulness are widely used to evaluate the practicality of instructional materials ([Zahara, 2023](#)). In this study, student responses were evaluated based on five aspects, namely visual design, content presentation, ease of use, effectiveness, and perceived benefits. These aspects include the attractiveness of the E-module display, clarity of material presentation, ease of operation, effectiveness in supporting learning activities, and the benefits obtained by students during the learning process ([Erniwati et al., 2022](#)). A total of 37 assessment items were distributed across these five aspects.

The practicality evaluation results from students indicate that the appearance aspect obtained percentages of 95% in class XI.B and 93.13% in class XI.C, both categorized as very practical. These results indicate that the layout, typography, color combinations, images, and videos in the E-module were attractive, clear, and comfortable to use during learning activities ([Peng et al., 2021](#)). Furthermore, the presentation aspect achieved percentages of 90.11% in class XI.B and 93.89% in class XI.C, indicating that the learning materials, instructions, and activity sequences were systematically organized and easy for learners to follow ([Safitri & Harahap, 2025](#)).

The practicality aspect also obtained high percentages of 91.89% in class XI.B and 92.78% in class XI.C. This finding indicates that the E-module was easy to access, operate,

and use independently or with teacher guidance, supported by flexible access through electronic devices, video features, and organized material presentation ([Erniwati et al., 2022](#)). Meanwhile, the effectiveness aspect reached 90.3% in class XI.B and 91.3% in class XI.C, indicating that the E-module was able to support learners in understanding fluid statics concepts and facilitate problem-solving activities during learning ([Erniwati et al., 2022](#)). In addition, the benefit aspect recorded percentages of 90.86% in class XI.B and 89.86% in class XI.C, which demonstrates that the E-module provided positive learning experiences, increased students' motivation to learn physics, and encouraged students to solve problem-solving questions independently ([Lastri, 2023](#)).

Overall, the total scores obtained were 169.75 for class XI.B and 170.95 for class XI.C out of a maximum score of 185, corresponding to practicality percentages of 91.76% and 92.41%, respectively, both categorized as "Very Practical." Referring to the established practicality criteria, a product is considered practical if it achieves a minimum percentage of 70% ([Pixyoriza et al., 2022](#)). Therefore, these findings indicate that the developed E-module has a high level of practicality and is feasible for implementation in the learning process.

In addition to student responses, teacher assessment is also important in determining the level of E-module practicality. As the main facilitator of classroom learning, teachers provide professional evaluations regarding the ease of use, attractiveness, and usefulness of instructional materials in real learning contexts ([Sitompul et al., 2025](#)). Teacher assessments covered five aspects, namely appearance, presentation, practicality, effectiveness, and benefits, using the same 37 assessment items.

The appearance aspect obtained a percentage of 95% and was categorized as very practical, indicating that the layout, typography, images, videos, and color combinations in the E-module were attractive, clear, and appropriate to support students' learning activities ([Peng et al., 2021](#)). The presentation aspect achieved 94.44%, showing that the organization of learning materials, instructions, and activity sequences was systematic and easy to implement during classroom instruction ([Safitri & Harahap, 2025](#)). Furthermore, the practicality aspect obtained a percentage of 96.67%, which indicates that the E-module was easy to operate, accessible through electronic devices, and flexible to use independently or through teacher guidance in different learning situations ([Erniwati et al., 2022](#)). The effectiveness aspect reached 87.5%, reflecting that the E-module was able to facilitate concept understanding and support problem-solving activities in physics learning ([Erniwati et al., 2022](#)). In addition, the benefit aspect indicates that the E-module provided positive impacts on learning activities, increased students' motivation to learn physics, and encouraged students to solve problem-solving questions independently ([Lastri, 2023](#)).

Overall, the total score obtained from teacher responses was 175.5 out of a maximum score of 185, resulting in a practicality percentage of 94.86%, which falls into the "Very Practical" category. Referring to the practicality criteria proposed by [Pixyoriza et al. \(2022\)](#), an E-module is considered practical if it achieves a minimum percentage of 70%. Therefore, these findings indicate that the developed E-module has a high level of practicality and is feasible for implementation in the learning process.

Based on both student and teacher responses, the developed E-module demonstrates a consistently high level of practicality. This suggests that the module is easy to use, beneficial, and suitable for supporting physics learning in classroom settings ([Ananda & Usmeldi, 2023](#)).

The Effectiveness of a Physics E-Module Based on the Problem-Based Learning Model on Static Fluid Material

The effectiveness of the E-module refers to the extent to which the instructional material achieves the intended learning outcomes, particularly in improving students' problem-solving skills. In instructional evaluation, effectiveness is commonly assessed by

comparing students' learning outcomes before and after the intervention using a pretest–posttest design, which allows the measurement of instructional impact on cognitive development ([Daeng et al., 2025](#)).

In this study, students' initial problem-solving abilities were measured through a pretest administered before the implementation of the E-module. The pretest consisted of 10 essay questions on the topic of static fluids. The results showed that the average pretest scores were 21.88 for class XI.B, 21.95 for class XI.C, and 21.85 for the combined classes, indicating that students' initial problem-solving abilities were still relatively low. After the implementation of the E-module, students' abilities were reassessed using a posttest with the same structure and topic. The average posttest scores increased significantly to 81.59 for class XI.B, 82.27 for class XI.C, and 82.07 for the combined classes. This improvement indicates that the E-module was able to support students in understanding static fluid concepts and solving contextual physics problems more effectively ([Yuliani et al., 2025](#)).

To measure the level of improvement, the normalized gain (N-gain) was calculated. This quantitative indicator serves as a refined metric for capturing the relative progression of learners by accounting for their initial baseline performance. N-gain is widely used to determine the effectiveness of learning interventions by comparing pretest and posttest scores ([Nabila et al., 2024](#)). The results showed N-gain values of 0.76 for class XI.B, 0.77 for class XI.C, and 0.77 for the combined classes, all of which fall into the “high” category. These findings indicate that the implementation of the E-module consistently contributed to improving students' problem-solving abilities across both classes.

The high N-gain values were influenced by the learning activities integrated into the E-module, such as contextual problem presentation, investigation activities, group discussions, practice questions, and evaluation tasks that encouraged students to analyze and solve problems systematically. In addition, the use of videos, illustrations, and examples related to everyday life helped students connect physics concepts with real situations and increased their active involvement during learning activities ([Saputri et al., 2023](#)). Consequently, students were not only able to understand concepts theoretically but also apply them in solving physics problems systematically. These findings are consistent with the study conducted by [Juliandha et al. \(2025\)](#), which reported that instructional materials developed using the problem-based learning approach can effectively improve students' problem-solving abilities because learners are actively involved in addressing contextual problems closely related to everyday life.

Overall, the findings indicate that the developed E-module was effective in improving students' problem-solving abilities on static fluid material. The integration of problem-based learning syntax, contextual problem-solving activities, and interactive multimedia features contributed to creating a more active, meaningful, and student-centered learning process. Therefore, the developed E-module is feasible to be used as a digital learning resource to support physics learning and enhance students' problem-solving skills in senior high school.

CONCLUSION

The problem-based learning-based E-module developed for static fluid material in grade XI high school demonstrated very valid, very practical, and effective results in improving students' problem-solving abilities. The E-module obtained a validity score of 92.64%, categorized as very valid. Student response scores reached 91.76% in class XI.B and 92.41% in class XI.C, while teacher responses reached 94.86%, all categorized as very practical. The effectiveness results showed average N-gain scores of 0.76 in class XI.B, 0.77 in class XI.C, and 0.77 overall, which were included in the high category based on Hake's classification. The novelty and main contribution of this study lie in the development of a problem-based learning E-module that integrates contextual problem-oriented activities into static fluid learning to specifically support students' problem-

solving abilities through more active, independent, and meaningful learning processes. The findings indicate that the developed E-module can be used as an effective digital teaching material in physics learning. However, this study was limited to a relatively small sample and implementation within a single school and topic area. Therefore, further studies are recommended to examine the application of the E-module in broader learning contexts and different educational levels.

CONFLICTS OF INTEREST

The authors confirm the nonexistence of any conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Ar served as the primary contributor to this study, being responsible for the conceptualization of the research, development of the methodology, data collection, formal analysis, and preparation of the original draft manuscript. Er contributed to the conceptual refinement of the study, provided academic supervision, and was involved in reviewing and editing the manuscript to ensure its scientific quality. Hnd. M. contributed to the validation of the research instruments, supervision of the research process, and critical revision of the manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT (OpenAI) as a tool for refining language and enhancing clarity in this manuscript. All AI-generated content was reviewed, revised, and confirmed for accuracy by the authors. Full responsibility lies with the authors. The study's design, data collection, analysis, and interpretation were conducted independently without AI assistance.

REFERENCES

- Adeduyigbe, A. M., & Okeke, U. K. (2025). Instructional design considerations: Cognitive physics comprehension in secondary education. *International Journal of Studies in Psychology*, 5(2), 1–4. <https://doi.org/10.38140/ijpspy.v5i2.1598>
- Al-Farisi, F. R., Yulianti, E., Hidayah, F., & Hidayat, D. H. Z. (2023). Enhancing student higher order thinking skills through problem-based learning media integration. *Jurnal Pendidikan Progresif*, 13(3), 1121–1134. <https://doi.org/10.23960/jpp.v13.i3.2023>
- Albina, M., & Pratama, K. B. (2025). Peran tujuan pembelajaran dalam perencanaan pembelajaran: Dasar untuk pembelajaran yang efektif. *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, 2(2), 55–61. <https://doi.org/10.62383/hardik.v2i2.1233>
- Ananda, P. N., & Usmeldi, U. (2023). Validity and practicality of e-module model inquiry based online learning to improve student competence. *Jurnal Penelitian Pendidikan IPA*, 9(4), 2010–2017. <https://doi.org/10.29303/jppipa.v9i4.3563>
- Antonius, A., Huda, N., & Suratno, S. (2022). Pengembangan e-modul interaktif pembelajaran gambar teknik berbasis keterampilan kreatif untuk siswa smk. *Jurnal Manajemen Pendidikan dan Ilmu Sosial*, 3(2), 1090–1102. <https://doi.org/10.38035/jmpis.v3i2>
- Apriliani, V., & Riyanto, R. (2025). Implementation of e-modules to support the teaching and learning process at pkbm sarana maju, tegal city. *Journal of Artificial Intelligence and Engineering Applications*, 4(2), 1386–1392. <https://doi.org/10.59934/jaiea.v4i2.913>
- Ariawan, R., Utami, R., Herlina, S., & Istikomah, E. (2022). Pengembangan modul ajar dengan model problem based learning berorientasi kemampuan pemecahan masalah. *GAUSS: Jurnal Pendidikan Matematika*, 5(1), 71–82. <https://doi.org/10.30656/gauss.v5i1.3930>
- Ariyanto, E. W., Handajani, S., Sutiadiningsih, A., & Widagdo, A. K. (2023). Pengembangan e-modul untuk kompetensi dasar menerapkan plain cake bagi siswa

- smkn 1 cerme gresik. *Jurnal Kajian Penelitian Pendidikan dan Kebudayaan (JKPPK)*, 1(3), 169–182. <https://doi.org/10.59031/jkppk.v1i3.290>
- Aswara, S., Amanda, F. D., & Fitriani, R. (2021). Pengaruh media pembelajaran fisika berbasis video untuk meningkatkan minat dan pemahaman konsep materi tekanan siswa sman 2 sungai penuh. *Integrated Science Education Journal*, 3(1), 16–23. <https://doi.org/10.37251/isej.v3i1.173>
- Bura, E. L., Yeyen, Y. Y., Suban, M. E., & Wajong, A. (2024). Analisis kemampuan pemecahan masalah peserta didik pada materi fluida statis berbantuan 3d pageflip Professional. *Journal on Education*, 6(3), 15871–15878. <https://doi.org/10.31004/joe.v6i3.5464>
- Busyairi, A., & Zuhdi, M. (2024). Profile of student misconceptions on static fluids: A meta-analysis study. *Kappa Journal Physics Education*, 8(3), 476–484. <https://doi.org/10.29408/kpj.v8i3.28433>
- Butar, Y., & Panggabean, D. D. (2022). Pengembangan e-modul pembelajaran fisika berbasis problem-based learning (pbl) pada materi hukum newton gerak kelas x di sma negeri 1 besitang. *Jurnal Inovasi Pembelajaran Fisika*, 10(2), 84–91. <https://doi.org/10.24114/inpafi.v10i2.35007>
- Chand, S. P. (2023). Constructivism in education: Exploring the contributions of piaget, vygotsky, and bruner. *International Journal of Science and Research*, 12(7), 274–278. <https://doi.org/10.21275/SR23630021800>
- Daeng, F. F., Alifah, D. R. Z. Z., Jatmiko, B., Supardi, Z. A. I., Alhusni, H. Z., & Citra, N. F. (2025). The effectiveness of black's principles with modeling-based learning (mbl) to improve students' science process skills. *Journal of Digitalization in Physics Education*, 1(3), 1–12. <https://doi.org/10.26740/jdpe.v1i3.45185>
- Darniyanti, Y., Sundahry, S., & Husni, R. (2023). Pendampingan dan penyuluhan pembuatan perangkat pembelajaran menggunakan web google sites bagi guru sd n 15 koto baru untuk meningkatkan kompetensi guru di era kurikulum merdeka. *Journal of Human and Education*, 3(2), 354–360. <https://doi.org/10.31004/jh.v3i2.231>
- Docktor, J. L., Strand, N. E., Mestre, J. P., & Ross, B. H. (2015). Conceptual problem solving in high school physics. *Physical Review Physics Education Research*, 11(2), 020106(1-13). <https://doi.org/10.1103/PhysRevSTPER.11.020106>
- Erniwati, E., Hunaidah, H., Nurhidayat, R., & Fayanto, S. (2022). The testing of e-module flip-pdf corporate to support learning: Study of interests and learning outcomes. *Journal of Education Technology*, 6(4), 586–597. <https://doi.org/10.23887/jet.v6i4.43857>
- Elvianasti, M., Kharisma, N. A. N., Irdalisa, I., & Yarza, H. N. (2022). Analisis kemampuan pemecahan masalah biologi peserta didik pada materi perubahan lingkungan. *Jurnal Penelitian Pembelajaran Fisika*, 8(1), 1–9. <https://doi.org/10.24036/jppf.v8i1.115191>
- Estianinur, E., Parno, P., & Latifah, E. (2020). Identifikasi kemampuan pemecahan masalah siswa materi fluida statis. *Briliant: Jurnal Riset dan Konseptual*, 5(3), 477–487. <https://doi.org/10.28926/briliant.v5i3.490>
- Faidar, I., Sakdiyah, S., & Aziz, A. (2023). Pengembangan modul elektronik sejarah berbasis problem-based learning (pbl) untuk siswa kelas xii di sma labschool usk. *Educational Journal of History and Humanities*, 6(4), 3071–3090.
- Fauzi, S. S., Erviyenni, E., & Albata, S. W. (2025). Validitas e-modul berbasis discovery learning pada materi hidrokarbon untuk kelas xi sma/ma sederajat. *Chemistry Education Practice*, 8(2), 257–267. <https://doi.org/10.29303/cep.v8i2.9294>
- Fauziah, Z., Susanti, D., & Sari, L. Y. (2023). Validitas e-modul pembelajaran berbasis proyek pada materi perubahan lingkungan untuk sma/ma. *Jurnal Pendidikan Tambusai*, 7(3), 21197–21201.
- Febrilla, P. Z., Yerimadesi, Y., Andromeda, A., & Alizar, A. (2024). Development of salt hydrolysis module based on problem based learning integrated with tpack to improve

- numeracy literacy skills of phase f sma students. *Jurnal Penelitian Pendi*, 10(10), 7861–7872. <https://doi.org/10.29303/jppipa.v10i10.8615>
- Fitriyani, F., Sudirman, S., & Andriani, N. (2021). Pengembangan modul elektronik android berbasis stem. *Jurnal Inovasi dan Pembelajaran Fisika*, 8(2), 228–235.
- Fuentes, M. D., & DPA. (2025). The development and validation of instructional materials for theories and practices on master in public administration. *International Journal of Environmental Sciences*, 11(21), 4681–4685. <https://doi.org/10.64252/2f666n08>
- Gita, D. R., Dewati, M., & Mulyaningsih, N. N. (2022). pengembangan e-modul fisika berbasis problem-based learning untuk meningkatkan keterampilan pemecahan masalah siswa. *SINASIS (Seminar Nasional Sains)*, 3(1), 52–61.
- Hake, R. (2002). Lessons from the physics education reform effort. *Ecology and Society*, 5(2), 1–42. <https://doi.org/10.5751/es-00286-050228>
- Hutasuhut, N., & Albina, M. (2025). Instrumen penelitian pendidikan. *BLAZE: Jurnal Bahasa dan Sastra dalam Pendidikan Linguistik dan Pengembangan*, 3(3), 177–190. <https://doi.org/10.59841/blaze.v3i3.2976>
- Irawan, I. D. A., Khusaini, K., Islamiyah, M., Basri, N. A., & Ardilla, S. L. (2026). Students ' conceptual understanding and difficulties on static fluids : A literature review. *Phi: Jurnal Pendidikan Fisika dan Terapan*, 12(1), 1–8. <https://doi.org/10.22373/p-jpft.v12i1.30339>
- Juliandha, C. E., Enawaty, E., Harun, A. I., Erlina, E., & Sasri, R. (2025). Efektivitas penggunaan modul ajar kurikulum merdeka berbasis problem based learning terhadap kemampuan pemecahan masalah pada materi asam basa. *Jurnal Pendidikan MIPA*, 15(2), 471–480. <https://doi.org/10.37630/jpm.v15i2.2344>
- Kardono, K. (2023). Penerapan model pembelajaran problem-based learning untuk meningkatkan hasil belajar mata pelajaran fisika. *Jurnal Perspektif Pendidikan*, 17(1), 36–51. <https://doi.org/10.31540/jpp.v17i1.2382>
- Kurniati, R. D., Andra, D., & Wayan, D. I. (2021). E-module development based on pbl integrated stem assisted by social media to improve critical thinking skill: A preliminary study. *IOP Conference Series: Earth and Environmental Science*, 1796(1), 1–9. <https://doi.org/10.1088/1742-6596/1796/1/012077>
- Kurniawan, P. Y., Subyantoro, S., & Pristiwati, R. (2023). Urgensi bahan ajar interaktif berbasis information and communication technologies (ict) dalam pembelajaran menulis. *Jurnal Ilmiah Wahana Pendidikan*, 9(1), 324–331. <https://doi.org/10.5281/zenodo.7527626>
- Kurniawan, R., & Syafriani, S. (2021). The validity of e-module based on guided inquiry integrated ethnoscience in high school physics learning to improve students ' critical thinking. *Journal of Physics: Conference Series*, 1876(1), 012067. <https://doi.org/10.1088/1742-6596/1876/1/012067>
- Lastri, Y. (2023). Pengembangan dan pemanfaatan bahan ajar e-modul dalam proses pembelajaran. *Jurnal Citra Pendidikan*, 3(3), 1139–1146. <https://doi.org/10.38048/jcp.v3i3.1914>
- Lefera, M., & Swart, A. J. (2024). Determining the degree of constructive alignment for learning outcomes of two modules in a course on management. *Academia Lasalliana Journal of Education and Humanities*, 6(1), 79–87. <https://doi.org/10.55902/XCCV1767>
- Marsa, P. B., & Desnita. (2020). Analisis media, sumber belajar dan bahan ajar yang digunakan guru fisika sma materi gelombang di sumatera barat ditinjau dari kebutuhan belajar abad 21. *Jurnal Eksakta Pendidikan*, 4(1), 81–88. <https://doi.org/10.24036/jep/vol4-iss1/422>
- Nabila, M., Mislinawati, M., & Fitriani, S. (2024). Pengaruh penggunaan media interaktif berbasis wordwall terhadap hasil belajar ipas materi sistem tata surya kelas vi sdn

- lamkunyet aceh besar. *Cendekia: Jurnal Pendidikan dan Pengajaran*, 2(10), 963–976.
- Najuah, N., Lukitoyo, P. S., & Wirianti, W. (2020). *Modul elektronik: prosedur penyusunan dan aplikasinya*. Yayasan Kita Menulis.
- Nilyani, K., & Ratnawulan, R. (2023). *E-modul fisika berbasis model problem-based learning terintegrasi pembelajaran abad 21: Energi alternatif dan pemanasan global*. Padang, Program Studi Pasca Sarjana Pendidikan Fisika Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Negeri Padang.
- Ningsih, Z., Handayani, R. D., & Prihatin, J. (2025). Meningkatkan keterampilan berpikir kreatif dan kolaborasi siswa melalui pengembangan bahan ajar ipa berbasis pjl terintegrasi etnosains. *Eduproxima: Jurnal Ilmiah Pendidikan IPA*, 7(4), 2368–2379. <https://doi.org/10.29100/v7i4.8688>
- Nisa, W. L., Ismet, I., & Andriani, N. (2020). Development of e-modules based on multi-representations in solid-state physics introductory subject. *Berkala Ilmiah Pendidikan Fisika*, 8(2), 73–81. <https://doi.org/10.20527/bipf.v8i2.7690>
- Opilah, B. S., Setiawan, I., & Hamdani, D. (2022). pengembangan instrumen tes berorientasi pada keterampilan pemecahan masalah siswa sma pada konsep gelombang mekanik. *Jurnal Ilmu Pembelajaran Fisika*, 1(2), 106–112.
- Pane, A. N., Andra, D., & Wayan, D. I. (2021). The development physics e-module based pbl-integrated stem to improve higher-order thinking skills on static fluid material. *IOP Conference Series: Earth and Environmental Science*, 1796(1), 1–6. <https://doi.org/10.1088/1742-6596/1796/1/012086>
- Panggabean, D. D., & Sembiring, S. S. (2022). Pembuatan e-modul fisika berbasis problem-based learning materi usaha dan energi. *Jurnal Pendidikan Fisika*, 11(2), 116–121. <https://doi.org/10.24114/jpf.v11i2.38467>
- Peng, X., Xu, Q., Chen, Y., Zhou, C., Ge, Y., & Li, N. (2021). An eye tracking study: Positive emotional interface design facilitates learning outcomes in multimedia learning?. *International Journal of Educational Technology in Higher Education*, 18(40), 1–18. <https://doi.org/10.1186/s41239-021-00274-x>
- Pereira, E., Nsair, S., Pereira, L. R., & Kimberly Grant. (2024). Constructive alignment in a graduate-level project management course: an innovative framework using large language models. *International Journal of Educational Technology in Higher Education*, 21(25), 1–21. <https://doi.org/10.1186/s41239-024-00457-2>
- Pixyoriza, P., Nurhanurawati, N., & Rosidin, U. (2022). Pengembangan modul digital berbasis stem untuk mengembangkan kemampuan pemecahan masalah. *Edumatica : Jurnal Pendidikan Matematika*, 12(01), 76–87. <https://doi.org/10.22437/edumatica.v12i01.17541>
- Prastiwi, V. D., Parno, P., & Wisodo, H. (2018). Identifikasi pemahaman konsep dan penalaran ilmiah siswa sma pada materi fluida statis. *Momentum: Physics Education Journal Identifikasi*, 2(2), 56–63. <https://doi.org/10.21067/mpej.v1i1.2216>
- Purnomo, A., Kanusta, M., Fitriyah, F., Guntur, M., Siregar, R. A., Ritongga, S., Nasution, S. I., Maulidah, S., & Listantia, N. (2022). *Pengantar model pembelajaran*. Yayasan Hamjah Diha.
- Putri, B. C., Hendri, M., & Rasmi, D. P. (2022). Analisis kebutuhan bahan ajar e-modul berbasis pendekatan stem dengan scaffolding untuk mendukung pembelajaran hybrid learning di sma. *Jurnal Pendidikan Matematika dan Sains*, 10(1), 43–49. <https://doi.org/10.21831/jpms.v10i1.45002>
- Putri, W., Danawan, A., & Suyana, I. (2023). Pengembangan modul problem-based learning (pbl) dalam meningkatkan kemampuan pemecahan masalah pada materi momentum dan impuls. *Prosiding Seminar Nasional Fisika*, 2(1), 338–348.
- Ramadhani, N. A., & Lubis, R. H. (2025). Development of a 5e learning cycle-based physics e-module on measurement to improve students' conceptual understanding. *Lensa: Jurnal Kependidikan Fisika*, 13(2), 328–344. <https://doi.org/10.33394/j->

[lkf.v13i2.17834](https://doi.org/10.22437/bio.v6i3.9551)

- Ringo, E. S., Kusairi, S., & Latifah, E. (2019). Profil kemampuan pemecahan masalah siswa sma pada materi fluida statis. *Jurnal Pendidikan: Teori, Penelitian dan Pengembangan*, 4(2), 178–187. <https://doi.org/10.22437/bio.v6i3.9551>
- Safitri, F. A., & Harahap, M. H. (2025). Pengembangan e-modul pembelajaran berbasis masalah menggunakan flip pdf professional pada materi momentum dan impuls. *Jurnal Inovasi Pembelajaran Fisika*, 13(2), 108–118. <https://doi.org/10.24114/inpafi.v13i2.67394>
- Safitri, L., Hidayati, N., & Suryanti. (2025). Integrating problem-based learning into e-modules: A development study with validation and student response analysis. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, 11(1), 397–409. <https://doi.org/10.33394/jk.v11i1.14836>
- Saputri, R., Wilujeng, I., Jumadi, J., Nurohman, S., & Purnama, A. Y. (2023). Development of pbl modul-el to improve problem solving students of physics education program. *Jurnal Penelitian Pendidikan IPA*, 9(10), 8376–8382. <https://doi.org/10.29303/jppipa.v9i10.4092>
- Selviani, F., Oktarisa, Y., & Haryadi, R. (2024). Pengembangan E-modul Berbasis Problem-Based Learning (PBL) Materi Pemanasan Global untuk Memfasilitasi Keterampilan Pemecahan Masalah Siswa. *Jurnal Pendidikan Tambusai*, 8(2), 20448–20457.
- Slamet, F., A. (2022). *Model Penelitian Pengembangan (R N D)*. Institut Agama Islam Sunan Kalijogo Malang.
- Sihombing, R. H., & Armanto, D. (2024). Pengaruh penerapan e-modul berbasis problem-based learning terhadap kemampuan pemecahan masalah matematis peserta didik smkn 5 medan. *Journal of Sains Cooperative Learning and Law*, 1(2), 497–513.
- Sitompul, A., Sinulingga, K., & Bunawan, W. (2025). Desain bahan ajar berbasis problem based learning (pbl) untuk meningkatkan keterampilan berpikir kritis dan pemecahan masalah fisika. *Jurnal Pendidikan Fisika*, 14(1), 13–26. <https://doi.org/10.24114/jpf.v14i1.64731>
- Suparni, S., & Nasution, F. (2025). *Panduan praktis penelitian dan pengembangan di bidang pendidikan*. Yayasan Berkah Litera Jaya Anggota IKAPI.
- Syathroh, I. L., Pratiwi, V., Iman, A., Yusron, A., & Suryaningrum, S. (2024). *Metode pengembangan bahan ajar*. PT. Mafy Media Literasi Indonesia.
- Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teacher of exceptional children: A sourcebook*. Leadership Training Institute for Special Education. University of Minnesota.
- Viyanti, V., Shintya, R. E., Rosidin, U., Suyatna, A., & Farawahidah, N. (2025). Analysis of project-based problem-solving skills of optical equipment material with heller and heller steps. *Jurnal Pendidikan IPA Indonesia*, 14(2), 241–250. <https://doi.org/10.15294/jpii.v14i2.23810>
- Wahrini, R., & Makmur, E. (2023). Pengembangan e-modul pembelajaran keselamatan kerja dan kesehatan lingkungan (k3l) kompetensi keahlian teknik instalasi tenaga listrik smk negeri 1 sedayu yogyakarta. *Jurnal Media Elektrik*, 20(3), 87–93. <https://doi.org/10.59562/metrik.v20i3.50831>
- Wiendari, K. H., Hakim, L., & Sulistyowati, R. (2023). Pengembangan e-modul fisika berbasis problem-based learning pada materi fluida statis untuk siswa sma. *JPF (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 11(2), 271–278. <https://doi.org/10.24252/jpf.v11i2.34424>
- Yuliani, H., Andani, T., & Nastiti, L. R. (2025). Integration of pbl-based e-modules in physics education: improving problem-solving skills on static fluid concept. *Jurnal Pendidikan Fisika*, 13(3), 384–399. <https://doi.org/10.26618/oddpg995>

Zahara, M. (2023). Pengembangan e-modul berbasis problem-solving pada materi pemanasan global. *Indonesian Journal of Science Learning*, 4(2), 101–113. <https://doi.org/10.15642/ijsl.v4i2.2582>

AUTHOR PROFILES



Ardian, email ardian03pfis@gmail.com, field of expertise: Physics Education (Development of Learning Materials), affiliation: Universitas Halu Oleo.



Erniwati, email erniwati@uho.ac.id, field of expertise: Physics Education and Material Physics, affiliation: Universitas Halu Oleo, Google Scholar Erniwati, Sinta ID 6000846.



Hunaidah M, email hunaidah@gmail.com, field of expertise: Physics Education, Atomic Physics and Science Education, affiliation: Universitas Halu Oleo, Google Scholar Hunaidah M, Sinta ID 6027252.