Interactive Digital Modules to Improve Students' Learning Outcomes in Fluid Materials

Enjel Vreticia[1*]; Bodi Gunawan[2]; Netriani Veminsyah Ahda[3]

[1,2,3]*Physics Education, Universitas Bengkulu, Indonesia*
[1*]*Corresponding Email: enjelvreticia@gmail.com*

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Abstract: This study aimed to develop an interactive digital module assisted by Lumi Education, examine its feasibility, determine improvements in students' learning outcomes, and identify students' responses in static fluid learning. The study employed research and development using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The module integrated Problem-Based Learning (PBL), contextual problems, multimedia visualization, digital worksheets, interactive quizzes, and immediate feedback. The implementation involved 30 Grade XI B students at SMA Negeri 11 Bengkulu City. Data were collected through expert validation sheets, pretest and posttest learning outcome tests, and student response questionnaires. Validation by three experts yielded an average feasibility score of 89%, categorized as highly feasible. Students' mean scores increased from 29 on the pretest to 87 on the posttest, with an N-Gain of 0.82, categorized as high. Student responses reached 89%, indicating an excellent response. These findings indicate that the module is highly feasible and supports interactive static fluid learning.

Abstrak: Penelitian ini bertujuan untuk mengembangkan modul digital interaktif berbantuan Lumi Education, menguji kelayakannya, menentukan peningkatan hasil belajar peserta didik, dan mengetahui respons peserta didik dalam pembelajaran fluida statis. Penelitian menggunakan metode penelitian dan pengembangan dengan model ADDIE yang meliputi tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Modul mengintegrasikan Problem-Based Learning (PBL), permasalahan kontekstual, visualisasi multimedia, lembar kerja digital, kuis interaktif, dan umpan balik langsung. Implementasi melibatkan 30 peserta didik kelas XI B SMA Negeri 11 Kota Bengkulu. Data dikumpulkan melalui lembar validasi ahli, tes hasil belajar berupa pretest dan posttest, serta angket respons peserta didik. Validasi oleh tiga ahli menghasilkan skor kelayakan rata-rata 89% dengan kategori sangat layak. Rata-rata skor peserta didik meningkat dari 29 pada pretest menjadi 87 pada posttest, dengan N-Gain sebesar 0,82 dalam kategori tinggi. Respons peserta didik mencapai 89% dengan kategori sangat baik. Temuan ini menunjukkan bahwa modul sangat layak dan mendukung pembelajaran fluida statis yang interaktif.

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A. Introduction

Education is one of the important factors that plays a role in improving the quality of a nation's human resources (HR). Based on Law Number 20 of 2003 Article 1 paragraph (1), education is defined as an effort that is carried out consciously and planned to create a learning atmosphere and learning process that allows students to actively develop their potential. Through this process, students are expected to develop spiritual strength, self-control, personality, intelligence, noble character, and various skills needed in social, national, and civic life. Thus, education aims to develop students' potential optimally in accordance with the goals of national education (Sanga & Wangdra, 2023).

Along with the development of science and technology, education systems are required to adapt to technological advances so that learning becomes more effective and relevant to the demands of the 21st century. Digital transformation in education represents one effort to improve learning quality through the use of technology that can increase student engagement and support the achievement of optimal learning outcomes (Yusuf et al., 2023). The integration of digital technology into instructional materials therefore provides opportunities to create learning environments that are more interactive, flexible, and responsive to students' learning needs.

Physics is one of the subjects that plays an important role in developing scientific thinking skills. It deals with natural phenomena represented through facts, concepts, principles, and laws whose validity can be examined through scientific methods. Physics also relies on mathematics as a tool for explaining and analyzing natural phenomena occurring in everyday life (Syahrial et al., 2022). However, physics learning is often perceived as abstract, making it difficult for students to construct meaningful understanding of the concepts being studied (Musliman & Kasman, 2022). Static fluid is one of the topics that students commonly find challenging because it involves concepts that are not always directly observable. The topic can also lead to misconceptions regarding its application in everyday situations when instruction emphasizes concepts and formulas without connecting them to real-world phenomena (Husniah et al., 2020).

These challenges may contribute to low student learning outcomes. Student learning outcomes represent academic achievements demonstrated through learning assessments, including examinations, assignments, and students' active participation in achieving predetermined learning objectives. In educational research, students' cognitive achievement is more appropriately examined through learning outcomes than through report cards or diplomas alone (Somayana, 2020). Learning outcomes in fluid mechanics are influenced by various factors, including students' motivation, interest in learning, and prior understanding of the material (Yanti et al., 2021). Consequently, addressing difficulties in understanding static fluid concepts requires instructional strategies that not only present theoretical explanations but also actively engage students in constructing and applying their understanding.

The need for such instructional innovation is also evident in the learning context of SMA Negeri 11 Bengkulu City. Based on an interview with a physics teacher, learning

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remains predominantly teacher-centered and tends to be monotonous. The teaching materials are mainly limited to printed textbooks and therefore provide limited opportunities for interactive learning. Although facilities such as electricity and LCD projectors are available, digital teaching materials have not been utilized optimally. In addition, the physics laboratory has been converted into a classroom, which limits the implementation of practical activities. Consequently, physics learning tends to remain conventional and less engaging, contributing to students' difficulties in understanding physics concepts, particularly static fluid materials. These conditions highlight the need for interactive digital learning resources that can enhance student engagement and facilitate conceptual understanding.

One potential solution is the development of interactive digital modules that actively involve students in the learning process. Unlike conventional instructional materials, interactive modules can combine learning content with animations, simulations, practice questions, and immediate feedback, allowing students to explore concepts and construct understanding more independently (Jafnihirda et al., 2023). This approach is consistent with previous research showing that guided-inquiry-based interactive e-modules can encourage students to explore concepts more actively and improve their understanding of physics, particularly static fluid materials (Yuniar et al., 2021). Interactive digital materials therefore have potential not only to improve access to learning resources but also to provide richer representations of abstract physics phenomena.

Problem-Based Learning (PBL) provides an appropriate pedagogical framework for strengthening the interactive characteristics of digital modules. PBL-based interactive modules that present contextual problems and incorporate multimedia features, such as videos, animations, and interactive quizzes, have been shown to improve students' conceptual understanding by directly engaging them in exploration and problem-solving activities (Marinda et al., 2023; Ulhaq et al., 2025). PBL can also foster creativity and develop important skills through systematic problem-solving processes (Nurmahasih & Jumadi, 2023). Through PBL, students have opportunities to express ideas, connect new information with prior experiences, and actively solve contextual physics problems (Melinda et al., 2024). Furthermore, PBL places students in authentic problem situations that encourage active participation and deeper conceptual understanding rather than reliance on rote learning (Kurniawan et al., 2023). Integrating PBL into an interactive digital module can therefore create a learning environment in which students are not merely recipients of information but active participants in investigating and solving physics problems.

Digital technology can further strengthen the implementation of PBL through interactive learning platforms such as *Lumi Education*. *Lumi Education* is a learning platform that can be accessed through a website or application on laptops and mobile devices. Its interactive video features allow teachers to incorporate various forms of interaction, including multiple-choice questions, short-answer activities, word-swipe activities, and image-swipe activities (Jaenudin et al., 2025). The platform also provides interactive videos, quizzes, educational games, course presentations, and other learning activities that can be

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used to increase student involvement during learning (Widayanti, 2021; Fuadi & Nurmala, 2025). These features make *Lumi Education* a potential platform for integrating multimedia content and interactive assessment into a structured PBL learning sequence.

Despite the growing body of research on digital learning media, several gaps remain to be addressed. Existing studies have generally examined digital learning media in broad contexts, while the specific integration of *Lumi Education* into physics learning, particularly static fluid materials, remains insufficiently explored. Although interactive modules and PBL have been investigated separately, limited research has examined their integration within a *Lumi Education*-assisted digital module for static fluid learning. Furthermore, previous studies have not comprehensively examined the feasibility of such a module, its potential to improve students' learning outcomes, and students' responses within the same development study. This gap indicates the need for a learning resource that combines interactive digital technology with a structured problem-based learning approach to address the conceptual and instructional challenges of static fluid learning.

The novelty of this study lies in the development of a PBL-based interactive digital module that utilizes the *Lumi Education* platform specifically for static fluid learning. Rather than functioning solely as a digital repository of instructional materials, the developed module integrates contextual problems, multimedia visualization, interactive activities, quizzes, and digital worksheets within a structured PBL learning sequence. The integration is designed to provide students with opportunities to engage with physics phenomena, explore concepts, solve contextual problems, and receive immediate feedback during the learning process. Thus, the contribution of this study is not merely the development of a digital learning medium, but the integration of an interactive technological platform and a pedagogically structured PBL approach into a learning resource designed for a conceptually challenging physics topic.

Based on these considerations, this study focuses on the development of an interactive digital module assisted by *Lumi Education* for static fluid learning and examines its feasibility, the improvement in students' learning outcomes following its implementation, and students' responses to its use. Through these three dimensions, the study seeks to provide empirical evidence regarding the quality and learning potential of the developed module while contributing to the development of innovative digital learning resources for physics education. The findings are expected to support teachers in utilizing interactive technology to create more engaging learning experiences and to provide a reference for the further development of technology-enhanced physics learning materials.

B. Method

This study employed a Research and Development (R&D) approach to develop an interactive digital module assisted by *Lumi Education* for static fluid learning. The R&D approach was selected because it enables the development of an instructional product and the examination of its quality and learning outcomes. The development procedure followed the ADDIE model, which consists of five stages: Analysis, Design, Development,

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Implementation, and Evaluation. The research activities conducted at each stage are described below.

The analysis stage involved identifying students' learning needs, existing learning conditions, the use of instructional media, and difficulties encountered in understanding static fluid materials. This analysis was conducted through an interview with a physics teacher using 20 open-ended questions. The design stage focused on developing the structure and visual appearance of the interactive digital module. The module was designed to contain learning materials, instructional videos, interactive quizzes, and practice questions. The development stage involved producing the module using the *Lumi Education* platform and incorporating interactive features, including videos, quizzes, and learning activities. After the module was completed, expert validation was conducted to assess its feasibility in terms of content, presentation, language, and media. The implementation stage involved trying out the developed module in classroom physics learning to examine changes in students' learning outcomes and their responses to the module. Finally, the evaluation stage was conducted to assess the quality of the developed module based on expert validation results, student responses, and improvements in learning outcomes.

The research was conducted at SMA Negeri 11 Bengkulu City. The population consisted of 90 Grade XI students. A purposive sampling technique was employed based on considerations relevant to the objectives of the study, resulting in 30 students from class XI B being selected as the research sample. The students participated in cognitive assessments through pretest and posttest activities and completed a response questionnaire after using the developed module. Expert validation involved three validators, consisting of two lecturers from the Physics Education Study Program at the University of Bengkulu and one physics teacher from SMA Negeri 11 Bengkulu City. The validators assessed the module based on its content, presentation, language, and media components.

Data were collected through interviews, questionnaires, and tests. The interview was used to identify learning conditions, instructional media use, and difficulties in learning static fluid concepts. The expert validation questionnaire consisted of 18 statements rated on a four-point Likert scale, covering content, presentation, language, and media aspects. The student response questionnaire consisted of 10 statements addressing the module's appearance, ease of use, and usefulness. The learning outcome test consisted of 10 multiple-choice questions with five answer options and was administered as a pretest and posttest to the 30 participating students. The overall research and development procedure is presented in Figure 1.

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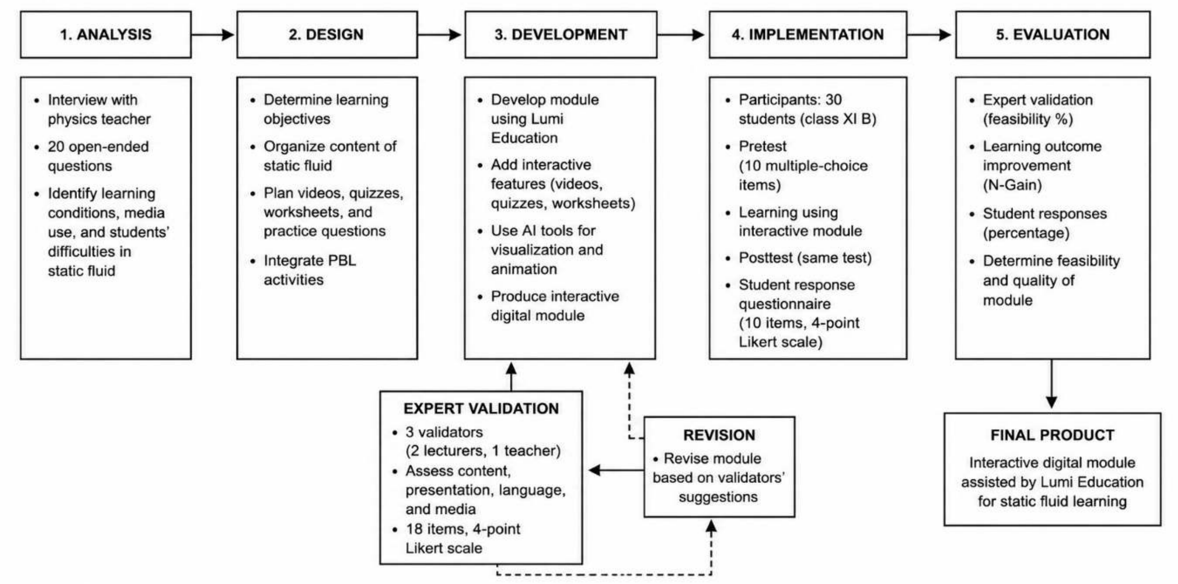

Figure 1. Research and Development Flow Using the ADDIE Model

C. Result

The development of the interactive digital module assisted by *Lumi Education* followed the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation stages. The development process resulted in an interactive module for static fluid learning that integrates learning materials, instructional videos, digital worksheets, interactive quizzes, and practice activities. The module was developed to support problem-based learning through contextual problems and interactive learning activities. The development and implementation results are presented in the following sections.

1. Analysis

The analysis stage identified the learning conditions, instructional media use, and students' difficulties in learning static fluid concepts. The interview with the physics teacher indicated that learning was still predominantly teacher-centered and relied mainly on printed textbooks. Although electricity and LCD projectors were available, digital learning materials had not been optimally utilized. In addition, the physics laboratory had been converted into a classroom, limiting practical activities. These conditions indicated the need for interactive digital learning materials that could provide students with more engaging learning experiences and support their understanding of static fluid concepts.

2. Design

At the design stage, the structure and appearance of the interactive digital module were developed based on the identified learning needs. The module consisted of static fluid materials supported by instructional videos, digital worksheets, interactive quizzes, and

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practice questions. The learning activities were organized using a Problem-Based Learning (PBL) approach, with contextual problems presented to encourage students to explore concepts and engage in problem-solving activities. The design of the module is presented in Figure 2.

Figure 2. Design of Lumi Education-Assisted Digital Modules

3. Development

The module was developed using the *Lumi Education* platform and incorporated interactive multimedia features. AI-based tools were also used to develop visual representations and animation videos of static fluid phenomena. The resulting visual content was integrated into the *Lumi Education* platform and supplemented with interactive questions. Interactive quizzes were used to provide opportunities for students to check their understanding and receive immediate feedback during learning activities.

Following development, the module was evaluated by three validators consisting of two Physics Education lecturers and one physics teacher. The validation results are presented in Table 4.

Table 4. Expert Validation Results

Validator	Percentage	Category
Validator 1	76%	Highly Feasible
Validator 2	96%	Highly Feasible
Validator 3	97%	Highly Feasible
Average	**89%**	**Highly Feasible**

The results show that all three validators assessed the module as highly feasible, with an average feasibility score of 89%. The assessment covered content, presentation, language, and media aspects. The percentage obtained for each validation aspect is presented in Table 5.

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Table 5. Feasibility by Assessment Aspect

Assessment Aspect	Percentage	Category
Content	87%	Highly Feasible
Presentation	92%	Highly Feasible
Language	89%	Highly Feasible
Media	89%	Highly Feasible

The highest score was obtained for the presentation aspect (92%), followed by language and media (89%), while the content aspect obtained 87%. All four aspects were categorized as highly feasible.

4. Implementation

The validated and revised module was implemented in class XI B at SMA Negeri 11 Bengkulu City. The implementation was conducted over three meetings with a total allocation of eight lesson hours (8 JP). During the implementation, students used the interactive module to engage with contextual static fluid problems, digital worksheets, quizzes, and interactive simulations. Student activities during the implementation are presented in Figure 6.

The improvement in students' learning outcomes was determined by comparing the pretest and posttest scores. The results are presented in Table 6.

Table 6. Students' Learning Outcomes and N-Gain

Indicator	Value
Average Pretest Score	29
Average Posttest Score	87
Maximum Score	100
N-Gain	0.82
N-Gain Category	High

The average score increased from 29 on the pretest to 87 on the posttest. The resulting N-Gain score was 0.82, which falls within the high category. The comparison between the pretest and posttest scores is illustrated in Figure 7.

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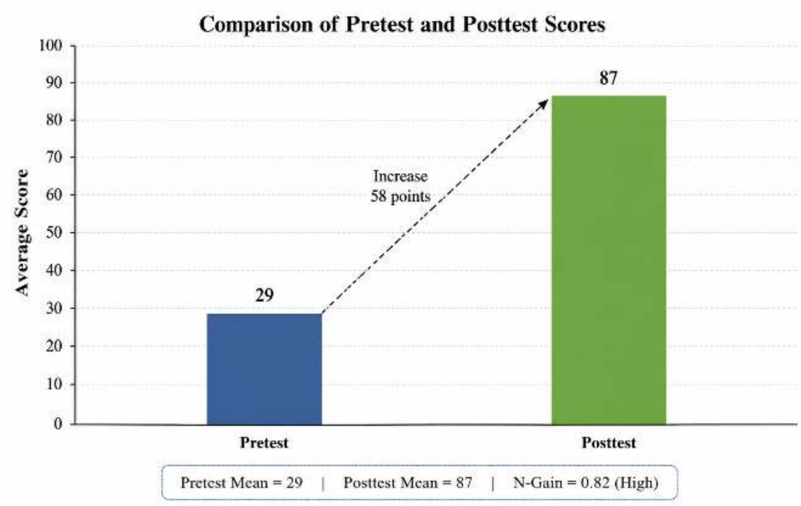

Figure 7. Pretest and Posttest Score Improvement

5. Student Responses

After completing the learning activities, students responded to the developed module through a questionnaire covering the material, media, and perceived benefits. The results are presented in Table 7.

Table 7. Student Responses to the Interactive Digital Module

Aspect	Percentage	Category
Material	90%	Excellent
Media	90%	Excellent
Benefits	88%	Excellent
Average	89%	Excellent

The results indicate that students gave positive responses to all assessed aspects. The material and media aspects each obtained 90%, while the perceived benefits aspect obtained 88%. Overall, the average student response was 89%, categorized as excellent.

D. Discussion

The findings show that the interactive digital module assisted by *Lumi Education* achieved a high feasibility level (89%), produced a high N-Gain of 0.82, and received an excellent student response (89%). The feasibility assessment was consistently high across content (87%), presentation (92%), language (89%), and media (89%). In addition, students' mean learning outcomes increased from 29 on the pretest to 87 on the posttest. These results indicate that the developed module was well received and was associated with substantial improvement in students' learning outcomes after its implementation.

The improvement can be explained by the way the module combines PBL-oriented activities with interactive digital features. Static fluid concepts that are difficult to observe

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directly were represented through videos, visualizations, interactive quizzes, digital worksheets, and contextual problems. These features provided students with opportunities to engage with problems, explore representations, and check their understanding through immediate feedback. The PBL framework provides the pedagogical explanation for this process because it places students in problem situations and encourages active engagement, exploration, and problem solving rather than passive reception of information. This interpretation is consistent with the implementation of contextual problems, digital worksheets, and interactive simulations reported in the study.

The findings are also supported by previous studies cited in the article. Kurniawan et al (2023) reported that PBL encourages active involvement and deeper conceptual understanding through authentic problem situations, while Sari et al (2023) found that PBL is consistently associated with improved physics learning outcomes through the development of critical thinking and problem-solving skills. Studies by Kasanah (2024) and Alfiaturrohmah et al (2024) similarly reported positive learning outcomes through PBL-assisted interactive media and electronic worksheets (E-LKPD). In the context of digital learning, Widayanti (2021) reported that *Lumi Education*-based interactive videos can increase students' learning interest, while Jaenudin et al (2025) examined the use of *Lumi Education*-based interactive videos in relation to student learning outcomes.

This study extends the existing literature by bringing these elements together in a single interactive learning resource specifically designed for static fluid learning. Previous research has examined interactive modules, PBL-based learning, or *Lumi Education*-based activities, whereas the present study integrates contextual PBL activities, multimedia representations, digital worksheets, interactive quizzes, and feedback within the *Lumi Education* platform. The contribution therefore lies not simply in using digital technology, but in aligning the technological features with a problem-based instructional structure for a physics topic that requires concrete representations. The excellent student response, particularly for the material and media aspects (90% each), further indicates that this integrated design was acceptable to the intended users.

Taken together, the findings provide an answer to the study's research focus: the developed *Lumi Education*-assisted interactive digital module was highly feasible, students demonstrated a high level of learning improvement (N-Gain = 0.82) following its implementation, and their overall response was excellent (89%). These results support the module's potential as an interactive resource for static fluid learning. However, because the study used a relatively small sample from a single class and did not employ a comparison group, the observed improvement should be interpreted as evidence of learning gain rather than definitive evidence of causal effectiveness. This distinction strengthens the interpretation of the findings and provides a basis for future studies involving larger and more diverse samples and comparative research designs.

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E. Implication

The findings have practical implications for physics education, particularly for the integration of digital technology into conceptually challenging topics such as static fluids. The developed module demonstrates that *Lumi Education* can be used to integrate PBL-oriented activities, multimedia representations, digital worksheets, interactive quizzes, and immediate feedback within a single learning environment. For teachers, the module provides an alternative instructional resource that can support more interactive and student-centered learning, while for students, its interactive features provide opportunities to engage with contextual problems and explore physics concepts through multiple representations. More broadly, the study suggests that effective digital learning design should align technological features with appropriate pedagogical strategies rather than treating technology merely as a medium for delivering content. Thus, the developed module can serve as a practical reference for teachers and educational developers seeking to design technology-enhanced physics learning materials that are interactive, contextual, and responsive to students' learning needs.

F. Limitations and Suggestions for Further Research

This study has several limitations that should be considered when interpreting the findings. First, the implementation involved only 30 students from a single class at SMA Negeri 11 Bengkulu City, which limits the generalizability of the findings to other student populations and school contexts. Second, the study focused exclusively on static fluid materials; therefore, the applicability of the developed module to other physics topics with different conceptual characteristics remains unexamined. In addition, the study employed a pretest–posttest design without a comparison group, so the observed learning gains cannot be attributed exclusively to the developed module.

Future research should involve larger and more diverse samples across multiple schools to examine the consistency and generalizability of the findings. Comparative or quasi-experimental designs could also be employed to provide stronger evidence regarding the contribution of the module to students' learning outcomes. Further studies may adapt the *Lumi Education*-assisted interactive module to other physics topics, particularly abstract concepts, and explore the integration of emerging technologies such as artificial intelligence (AI) and virtual reality (VR). Future research may also examine its potential to develop higher-order thinking skills, including critical thinking, problem-solving, and creativity.

G. Conclusion

The developed module offers a practical approach to integrating interactive digital technology with Problem-Based Learning in static fluid instruction. Its design connects contextual problems, multimedia representations, digital worksheets, interactive assessment, and feedback within a coherent learning environment, enabling students to engage more actively with physics concepts. The study therefore contributes a technology-

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enhanced learning resource that aligns pedagogical design with the characteristics of abstract physics content. Although further validation in broader educational settings is needed, the findings provide a foundation for extending *Lumi Education*-assisted interactive learning to other physics topics and instructional contexts.

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Author's Biography

	**Enjel Vreticia.** She was born on December 25, 2026 in Senali. She holds a Bachelor of Education (S.Pd.) degree from the University of Bengkulu (Unib). Email: enjelvreticia@gmail.com
	**Bodi Gunawan.** He was born on September 26, 1988. He is a lecturer in the Physics Education Department at the University of Bengkulu. He holds a Bachelor of Education (S.Pd.) degree and a Master of Science (M.Si.) degree. Email: bodi.gunawan@unib.ac.id
	**Netriani Veminsyah Ahda.** She was born on November 9, 1997. She is a lecturer in the Physics Education Department at the University of Bengkulu. She holds both a Bachelor of Science (B.Sc.) and a Master of Science (M.Sc.) degree from IPB University. Email: nvahda@unib.ac.id