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E-Learning of Static Fluids Utilising Problem-Based Learning via the Edukati Platform to Encourage Students' Critical Thinking Skills

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Abstract: *This study aims to develop e-learning media based on Problem Based Learning (PBL) with the help of the Edukati platform on static fluid material to train students' critical thinking skills. The problems in this study are the low empowerment of critical thinking skills in physics learning and the lack of learning media that support independent and contextual understanding of concepts. The research employed the Research and Development (R&D) method using the ADDIE development model, which includes the stages of analysis, design, development, implementation, and evaluation. Validation was conducted by four experts (media expert, subject matter expert, technical expert, and pedagogical expert), and practical testing involved teachers and students from MA Muhajirin Kampar. The e-learning platform is equipped with videos, e-modules, e-worksheets, interactive quizzes, discussion forums, and exams aligned with PBL syntax and critical thinking indicators. The validity results from media, content, technical, and pedagogical experts yielded an average validity score of 3.52, indicating that the developed e-learning platform is highly valid. The responses from teachers and students showed enthusiasm and comfort with the developed media, achieving an average practicality score of 3.62 (very practical) and 3.55 (very practical). Therefore, the PBL-based Fluid Statics e-learning is suitable for enhancing critical thinking skills among high school/MA students in grade XI.*

Keywords: *critical thinking skills, edukati platform, e-learning, problem based learning, static fluid*

E-Learning Fluida Statis berbasis *Problem Based Learning* berbantuan *Platform* Edukati untuk Melatih Kemampuan Berpikir Kritis Siswa

Abstrak: Penelitian ini bertujuan mengembangkan media pembelajaran e-learning berbasis *Problem Based Learning* (PBL) dengan bantuan *platform* Edukati pada materi fluida statis untuk melatih kemampuan berpikir kritis siswa. permasalah pada penelitian ini adalah rendahnya pemberdayaan kemampuan berpikir kritis dalam pembelajaran fisika serta kurangnya media pembelajaran yang mendukung pemahaman konsep secara mandiri dan kontekstual. Penelitian menggunakan metode *Research and Development* (R&D) dengan model pengembangan ADDIE yang mencakup tahapan analisis, desain, pengembangan, implementasi, dan evaluasi. Validasi dilakukan oleh empat ahli (ahli media, ahli materi, ahli teknis dan ahli pedagogi) dan uji praktikalitas melibatkan guru serta siswa MA Muhajirin Kampar. *E-learning* ini dilengkapi video, e-modul, e-LKPD, kuis interaktif, forum diskusi dan ujian yang disesuaikan dengan sintaks PBL dan indikator berpikir kritis. Hasil validitas dengan ahli media, materi, teknis dan pedagogi mendapatkan skor rata-rata validitas 3,52 yang artinya *E-learning* yang dikembangankan sangat valid. Hasil Respon guru dan siswa menunjukkan antusiasme dan kenyamanan terhadap media yang dikembangkan dengan memperoleh skor rata-rata praktikalitas sebesar 3,62 (sangat praktis) dan 3,55 (sangat praktis). Dengan demikian, *e-learning* Fluida ststis berbasis PBL layak digunakan untuk meningkatkan kemampuan berpikir kritis siswa SMA/MA kelas XI.

Kata kunci: *e-learning*, fluida statis, kemampuan berpikir kritis, platform edukati, *problem based learning*

INTRODUCTION

The demands of the 21st century necessitate that each student cultivates specific cognitive and interpersonal abilities to thrive in both academic and professional realms (Chusna et al., 2024). A vital cognitive ability necessary for the 21st century is the capacity for critical analysis (Septeanawati & Yulianti, 2021; Zamriani et al., 2023). The education system must prioritise cultivating critical thinking skills among students in schools, enabling them to effectively navigate the complexities of the 21st century upon graduation (Elitasari, 2022; Sakdiah et al., 2022)

Students' critical thinking abilities are not being fully harnessed within the educational framework of Indonesian schools, particularly in the context of physics instruction. The critical thinking abilities of high school students across various cities in Indonesia remain underutilised (Yusa, 2023). Consequently, enhancing students' critical thinking abilities has become a paramount objective that necessitates attention and cultivation.

Critical thinking skills encompass the ability to analyse information adeptly, employ strategic approaches in decision-making, generate innovative ideas, engage in logical inquiry, articulate conclusions, evaluate evidence and conclusions, assess with considerable accuracy, and scrutinise underlying assumptions (Sardi et al., 2022). The components of critical thinking encompass six key indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation (Ennis, 2013; Kusumah, 2019; Zulfawati & Mayasari, 2021).

Using educational models may develop critical thinking abilities (Hamdani M et al., 2019). Robbert H. Ennis (2013) six indications of critical thinking abilities, as referenced in Munawwarah et al. (2020), may be cultivated at each stage of the problem-based learning (PBL) model's syntax. During the first phase of the PBL process, which involves familiarising pupils with the issue, educators may cultivate critical thinking abilities in interpretation and analysis. Subsequently, during the student organisation phase, educators might cultivate the indicators of inference-related critical thinking abilities. Subsequently, during the inquiry phase, educators may cultivate critical thinking abilities related to explanation and self-regulation. During the final product development phase, educators may cultivate critical thinking abilities in interpretation, explanation, and self-regulation. In the concluding stage, analysis and assessment, educators may cultivate indications of critical thinking abilities related to analysis and evaluation. Numerous studies indicate that Problem-Based Learning (PBL) may enhance students' critical thinking abilities (Amanda et al., 2025; Apriani et al., 2025; Molamahu et al., 2025)

The needs analysis conducted at MA Muhajirin identified many factors that impede the efficacy of physics education. Physics instruction often depends on texts that the school library supplies, which are insufficient for facilitating independent study. Moreover, textbooks are marketed at elevated costs. The scarcity of textbooks results in pupils' reliance on existing materials. Moreover, the content in the textbooks lacks enough diversity of questions and real-life application examples, hindering students' comprehension of physics ideas.

A further barrier hindering comprehension of ideas is the use of learning material that employs ICT in the form of e-learning, which is not yet widely adopted via electronic devices such as laptops or smartphones. Thorough contemplation of topics in physics education is crucial, since this discipline is interconnected with students' experiences and observations of daily occurrences. Physics ideas often include abstract entities, existing only as mental representations inside an individual's cognition, devoid of tangible from (Abdilah et al., 2024; Musliman & Kasman, 2022). Understanding one's capabilities

necessitates the ability to differentiate, anticipate, elaborate, provide illustrations, infer, rephrase, and formulate assessments

Given the recent advancements in science and technology, instructors are expected to provide inventive learning materials and progressive curriculum development that align with student demands. E-learning, which employs electronic media, is a technology that may facilitate the learning process. The rapid advancement of ICT significantly enhances the design of e-learning that incorporates text, photos, videos, simulations, animations, quizzes, and interactive assessments (Saprudin et al., 2021). E-learning facilitates the incorporation of audio-visual components, sound, video, and navigation into educational activities, enhancing student engagement with the planned e-learning medium(Suhardiman et al., 2022). Educational apps are web-based platforms that may facilitate learning via e-learning, provided they are developed well (Tandirerung & Mangesa, 2022). Educational apps allow instructors to engage with learning materials via audio-visual presentations, sound, text, and interactive quizzes.

E-learning is a progression in educational methodologies, functioning as a pedagogical system delivered by electronic devices, including computers, tablets, or smartphones(Puspitasari & Jamaluddin, 2018). The Edukati e-learning platform offers enhanced ease for students to access educational information anytime and anywhere.

E-learning has self-instructional, self-contained, stand-alone, adaptable, and user-friendly attributes(Alsahou et al., 2022; Hamutoglu et al., 2021). These attributes facilitate e-learning in enhancing the efficacy of the learning process and augmenting students' critical thinking abilities. This medium enables students to autonomously engage in learning activities and processes. E-learning is a self-directed resource that enhances students' critical thinking abilities(Haghparast et al., 2014). Consequently, creating interactive e-learning using PBL-based educational apps focused on static fluid content is essential to cultivate students' critical thinking skills. The use of PBL in instructing static fluid concepts entails introducing authentic challenges that students face in their everyday experiences.

METHOD

This study is categorised as research and development (R&D). This strategy involves developing a specific product and evaluating its validity and practicality (Sugiyono, 2022). The development process adheres to the phases of the ADDIE model: analysis, design, development, implementation, and evaluation.

The tools used in this developmental research included answer questionnaires, validation forms, and practicality evaluations. Four experienced evaluators conducted the validation procedure. After the validation phase, a limited-scale feasibility assessment of the educational medium was performed. The exam was conducted at MA Muhajirin Kampar, including 21 eleventh-grade students and three physics instructors.

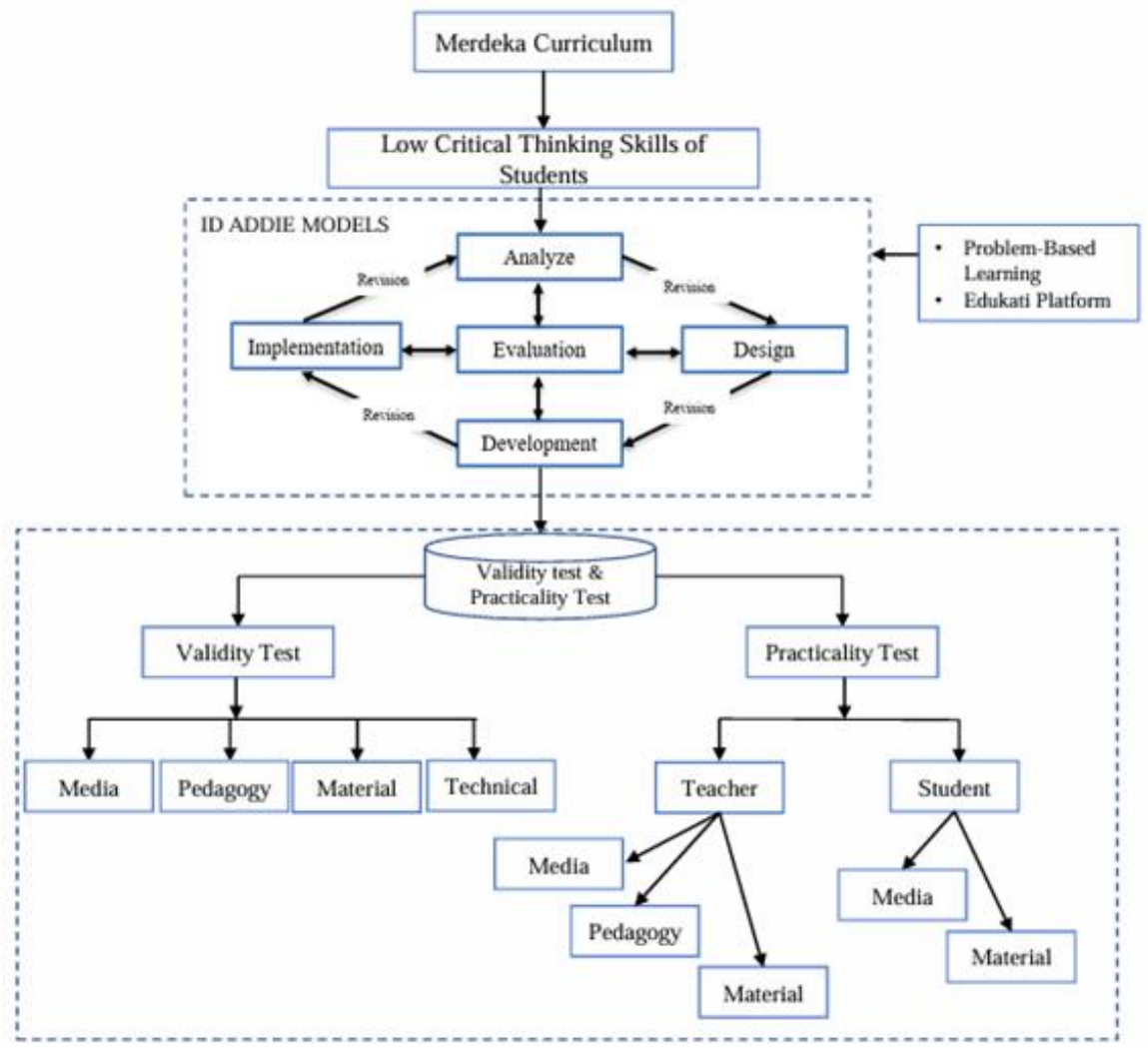


Figure 1. Research Procedure

The efficacy of the established e-learning is shown by the results of the descriptive analysis, which elucidates the quantitative data derived from questionnaires completed by experts. The validity evaluation questionnaire was constructed using the Likert scale, which evaluates the attitudes, views, and perceptions of people or groups (Arikunto, 2002; Setyosari, 2013). The validity categories were established based on the mean score of each item on the Likert scale, as shown in Table 1.

Table 1. Validation Index (Septiani et al., 2021)

No	Validation Index	Category
1	$3.50 < \bar{x} < 4.00$	Very Valid
2	$3.00 < \bar{x} < 3.50$	Valid
3	$1.00 < \bar{x} < 3.00$	Invalid

An e-learning component is deemed legitimate if every validity assessment component has a minimum score of 3.00. If any assessment indicator falls below 3.00, the category is deemed invalid, necessitating correction or revision of the indicator, followed by retesting for validity until it meets the required standard.

This research employs descriptive analytic approaches for the practicality test, detailing quantitative data from the scores on the practicality sheets of e-learning media provided by instructors and students. The procedure for descriptive analysis involves aggregating the data for each indication on the practicality sheet. The average is then computed. E-learning is deemed practical if the average evaluation falls between the practical and convenient categories, as seen in Table 2.

Table 2. Practicality Criteria (Sugiyono, 2022)

No	Average Score	Category
1	$3.25 < \bar{x} < 4.00$	Very Practical
2	$2.50 < \bar{x} < 3.25$	Practical
3	$1.75 < \bar{x} < 2.50$	Impractical
4	$1.00 < \bar{x} < 1.75$	Very Impractical

RESULTS AND DISCUSSION

Creating e-learning material using the Edukati platform for physics, particularly static fluids, employs the ADDIE development paradigm. The ADDIE paradigm has five stages: analysis, design, development, implementation, and evaluation. This research progressed e-learning development to the practical level. The e-learning instructional media were evaluated via validity testing and practicality testing. Validity testing involved specialists from various fields, including subject matter experts, media experts, technological experts, and instructional design experts. Practicality testing was conducted through individual trials, small group trials, field trials, and evaluations from both teachers and students. The presentation of study findings and evaluations will be elucidated following the ADDIE framework.

Analysis

A needs analysis was performed to identify topics that may serve as the foundation for the research. The requirements analysis data were acquired via a questionnaire administered to 53 students at MA Muhajirin Kampar who had previously studied static fluid concepts. Figure 2 illustrates the outcomes of the needs analysis.

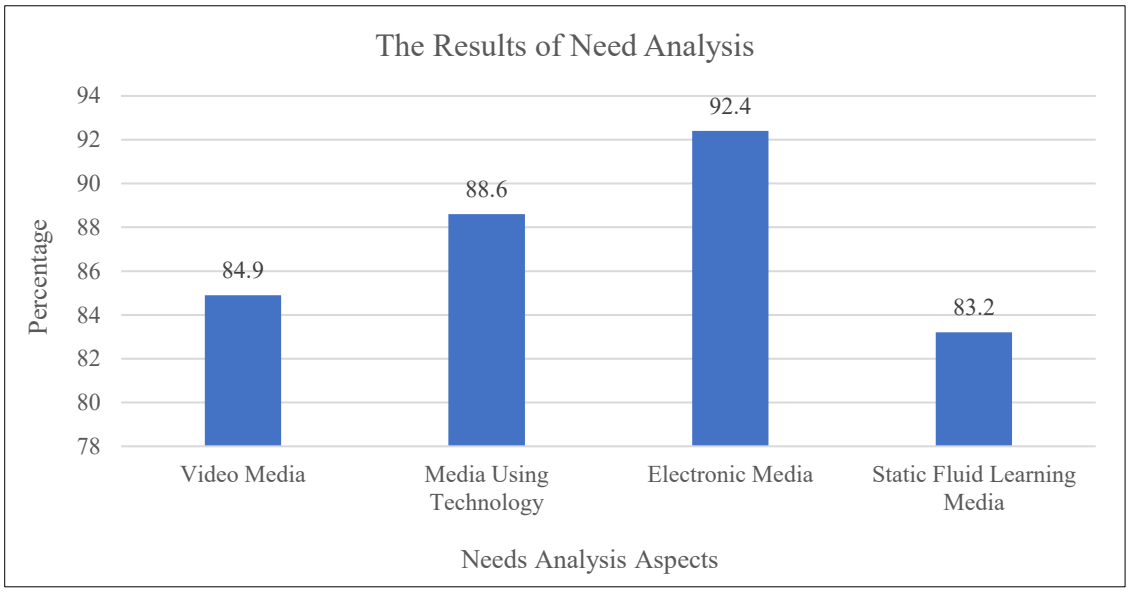


Figure 2. The Results of Need Analysis

A questionnaire administered to 53 respondents revealed that 84.9% of students preferred studying using videos, while 88.6% expressed comfort with technology-enhanced learning. Simultaneously, 92.4% of students favoured electronic learning media, while 83,2% said that static fluid materials need electronic media to enhance learning.

In light of these findings, it is imperative to devise alternative pedagogical approaches integrating technology to provide more intricate explanations, such as e-learning. E-learning is a learning approach that uses integrated technology, information, and communication to enhance the quality of student learning (Elyas, 2018). E-learning may enhance interaction between educators and learners, thereby augmenting students' critical thinking abilities (Singh et al., 2024), science process skills (Patabang et al., 2020), and metacognitive (Yusuf & Widyaningsih, 2020). E-learning is accessible anytime and anywhere, enabling students to examine content conveniently (Arrazi & Diyana, 2024; Inggriyani et al., 2019).

Document observation revealed that pupils' lowest average daily test scores were in fluid material, particularly static fluid. Students said in the facility study that static fluid material posed more challenges than other materials due to its complexity and difficulty in comprehension. The suitable amenities offered by MA Muhajirin, including smart TVs and Chromebooks, may be used for e-learning resources that comprise diverse learning activities. 92,4% of students endorsed using e-learning for the static fluid mechanics curriculum.

Design

In the design phase, media planning and design are executed by identifying the many requirements for the development process. The first step in the design phase is to create a media content outline to serve as a reference for e-learning creation. This media content outline encompasses the key elements of static fluid material developed under the problem-based learning (PBL) methodology. The methodical formulation of the media content outline seeks to align the learning progression with student requirements and material attributes. Asyhar (2021) asserts that the media material outline functions as a fundamental framework that directs the creation of educational material and activities to ensure they stay focused and relevant.

The subsequent step included the creation of a material outline, including sub-themes and descriptions of static fluid content, structured in accordance with the learning outcomes (CP) and learning objective flow (ATP) of the merdeka curriculum. At this juncture, the content was structured according to the idea of contextual learning, enabling students to connect the notion of static fluids to real-world occurrences, while concurrently facilitating problem-based learning (Molamahu et al., 2025). Alongside the content descriptions, visual alternatives including instructive photos, instructional films, e-Worksheets for students, and assessment tools were developed to facilitate active student involvement in online learning. The variety of learning material is crucial as it may engage different learning styles in children (Mayer, 2009).

The design of an e-learning framework delineating the architecture of digital modules, including the introduction, issue presentation, idea investigation, debate, and evaluation. This framework is then converted into a storyboard, which visually delineates the sequence of user interface interactions, content arrangement, navigation, and multimedia components on each educational page. According to Nasir & Fakhruddin (2023), storyboards reduce mistakes in media creation and enhance the production process of digital content. The LMS interface design is crafted with attention to user interface (UI)

and user experience (UX) concepts to guarantee that the e-learning platform is both aesthetically pleasing and user-friendly for students. The interface design must facilitate accessibility, provide simple navigation, and enable intuitive interaction (Tandirerung & Mangesa, 2022). The Edukati platform was selected as the Learning Management System (LMS) because to its characteristics that facilitate the execution of the PBL paradigm, including discussion forums, quizzes, and integrated assignment submissions. The Edukati LMS is anticipated to promote collaborative and interactive online learning, as noted by Arrazi & Diyana (2024), indicating that a user-friendly LMS may improve motivation and learning efficacy.

In the concluding phase of the design process, a validation instrument for e-learning was created for utilization by subject matter experts, media specialists, and educational professionals. This validation tool encompasses metrics for content quality, visual design, functionality, and adherence to PBL principles. This validation seeks to confirm that the e-learning product is appropriate for educational purposes and may facilitate the enhancement of students' critical thinking abilities (Sugiyono, 2022). Consequently, the design phase in this study is essential for guaranteeing the quality of static fluid e-learning development, ensuring alignment with curriculum requirements, student attributes, and the goal of enhancing critical thinking skills via the Problem-Based Learning approach.

During the design phase of e-learning media, researchers used the Edukati platform to develop the menu structure for the learning process flow, including characteristics pertinent to e-learning. The e-learning menu layout of the Edukati platform has multiple primary menus, including home, dashboard, and my course. Figure 3 illustrates the flowchart diagram of the static fluid PBL e-learning system designed to enhance critical thinking abilities.

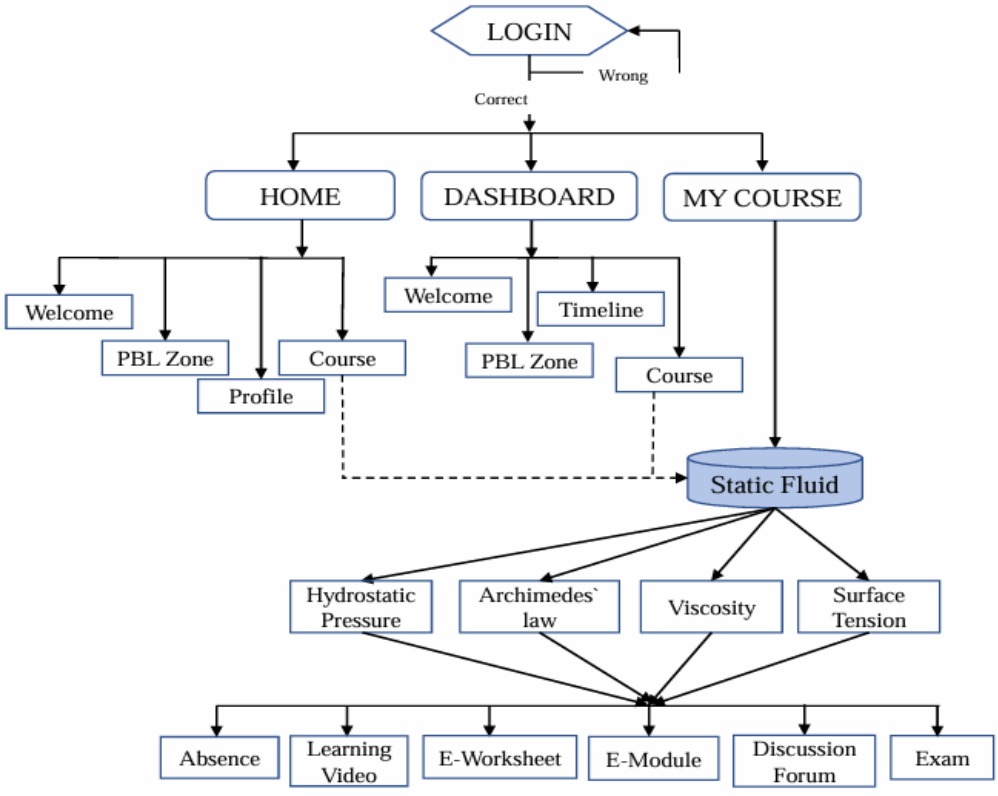
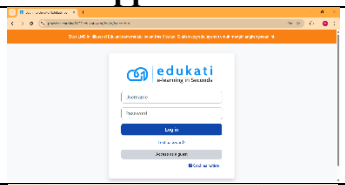
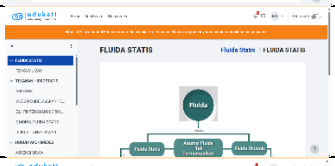


Figure 3. Flowchart E-learning

Development

During the development phase, the concepts and designs developed in the design stage are transformed into a product, which then undergoes media, material, technical, and educational specialists validation. The implementation phase must correspond with the previously established design phase and fulfil the specified criteria. The actions conducted during the development phase, including the creation and advancement of a problem-based learning static fluid e-learning program aimed at enhancing students' critical thinking abilities, are shown in Table 3.

Table 3. E-learning Storyboard on Static Fluids

No	Appearance	Information
1		Through the link: https://physicselearning2025.edukati.com students will then be directed to the login page to enter their username and password.
2		After logging in, students will see the e-learning menu, which includes Home, Dashboard, and My Courses. This display is located in the Home menu, which contains the e-learning title, PBL syntax, developer profile, and available classes.
3		The dashboard menu also includes e-learning titles, PBL syntax, timelines, and my classes.
4		In the my course menu, students will see the static fluid class.
5		In the static fluid class, students will first be given a concept map and four subchapters of material, namely hydrostatic pressure, Archimedes' law, viscosity, and surface tension.
6		In the subchapter section, there are attendance records, integrated h5p learning videos, e-LKPD, e-modules, question and answer discussion forums, and quizzes.

After the e-learning program was developed, validity and practicality tests were conducted. Based on the validity and practicality tests, the following results were obtained:

The Expert Validity

The validity test of e-learning with an edukati platform based on Problem-Based Learning for static fluids was conducted by four experts: subject matter experts, media experts, technical experts, and pedagogical experts. The results of the validation conducted are shown in Table 4.

Table 4. The Results of the Expert Validity Test

No	Aspect	Indicator	Average Score
1	Media	Appearance	3,80
		Images	3,65
		Instructions	3,40
2	Pedagogy	Presentation	3,55
		PBL aspect	3,45
		Critical thinking	3,50
3	Materials	Material suitability	3,32
		Accuracy of material	3,35
		Test	3,35
		Language	3,75
4	Technical	Controlling	3,80
		User	3,70
Average			3,52

The validity assessment performed by media experts, subject matter experts, technological experts, and pedagogical experts revealed that the validity ratings for each evaluated element were consistently 3,32-3,80. According to the validity index criteria, it may be concluded that every examined aspect falls inside the valid category. The average expert validation index for e-learning via the Educakati platform, using Problem-Based Learning to improve students' comprehension of static fluid concepts, is 3,52. According to Table 1, the validation index for e-learning using the Educakati platform, grounded on Problem-Based Learning to improve students' comprehension of static fluid concepts, is very valid. This corresponds with the study by Affandi et al. (2020), which indicates that e-learning as an educational medium effectively enhances students' learning outcomes, exhibiting a minimum effectiveness value of 21.72% and a maximum of 94.47%, with an average of 69.67%. This indicates that e-learning is suitable for the educational process and is classified as excellent by expert validation evaluation.

The Teachers` Practicality

After the validation test, three physics teachers conducted a practicality test of e-learning using an educational platform based on Problem-Based Learning to train students' critical thinking skills in static fluid material. The results are shown in Table 5.

Table 5. The Results of Teachers` Practicality

No	Aspect	Indicator	Practicality Score		
			Teacher 1	Teacher 2	Taecher 3
1	Media	Appearance	3,4	3,3	3,5
		Program	3,3	3,5	3,6
2	Pedagogy	Presentation	3,6	3,7	3,8
		PBL aspect	3,9	4,0	3,8
		Critical thinking	4,0	3,8	4,0
3	Materials	Material suitability	3,4	3,2	3,3
		Accuracy of material	3,5	3,4	3,3
		Test	3,7	3,5	3,6
		language	4,0	4,0	3,9
Average			3,64	3,60	3,64

The practicality assessment undertaken by educators revealed that the results for each evaluated component varied from 3.3 to 4.0. According to the practicality criteria in Table 2, it can be said that each evaluated feature is classified as very practical. The aggregated and averaged practicality score for educators for e-learning using the Problem-Based Learning oriented Edukati platform for enhancing students' critical thinking abilities on static fluid content is 3,62. According to Table 2, the practicality of e-learning using a Problem-Based Learning educational platform for developing critical thinking abilities in static fluid concepts is categorised as very practical. This aligns with the study of Yetti & Ahyanuardi (2020), which asserts that LMS-based modules in Simulation and Digital Communication education, according to teacher and student feedback, have been deemed effective.

The Students Practicality

21 MA Muhijirin students conducted a practical test of e-learning using the PBL-based edukati platform to train students' critical thinking skills on static fluid material. The results are shown in Table 6.

Table 6. The Results of Students` Practicality

No	Aspect	Indicator	Practicality Score
1	Media	Appearance	3,67
		Program	3,53
2	Pedagogy	Presentation	3,70
		PBL aspect	3,40
		Critical thinking	3,45
Average			3,55

According to Table 6, the practicality ratings of the produced e-learning vary from 3.40 to 3.70. According to the practical criteria outlined in Table 2, it can be said that every facet of e-learning falls inside the very practical group. The students' aggregated and averaged practicality scores indicate that the e-learning system using a Problem-Based Learning framework for enhancing critical thinking abilities in static fluid concepts yields a score of 3,55. According to Table 2, the e-learning system, which utilizes a Problem-Based Learning framework to enhance students' critical thinking abilities in static fluid content, is classified as highly practical. This corresponds with the study of Yetti & Ahyanuardi (2020), which asserts that LMS-based learning modules in Digital Simulation and Communication, according to teacher and student feedback, have been regarded as practical. Practicality pertains to the user-friendliness of e-learning.

The study's findings indicates that the development of e-learning using Problem-Based Learning (PBL) for static fluid content is both legitimate and feasible as a medium for enhancing students' critical thinking abilities. The development process was conducted methodically using the ADDIE model phases, which have shown efficacy in creating educational aids (Branch, 2009). The choice to include the PBL technique into this medium was predicated on the attributes of static fluid content, necessitating conceptual comprehension and analytical proficiency, in accordance with the aims of problem-based learning.

The product's validity, as assessed by professionals, is categorised as valid, with an average score of 3.52. This signifies that the design elements, content precision,

instructional methodology, and technological features have been well crafted. The assessment of validity by many experts offers a thorough analysis of the product's quality, according with the principles of educational instrument validation grounded on multiple expert evaluations (Johnson & Christensen, 2014).

From a pragmatic perspective, educators and learners assigned elevated ratings, indicating that the medium is user-friendly, comprehensible, and facilitates efficient learning processes. The average practicality score assigned by Teachers was 3.62, while the average score given by students was 3.55, both falling within the extremely practical category. This accomplishment demonstrates that the product is both theoretically advanced and practically relevant in actual classroom settings. Hannafin and Land (1997) assert that the efficacy of technology-based learning is influenced not only by its content but also by how that knowledge is presented and implemented in practice.

The effective deployment of the Edukati platform in e-learning demonstrates that using a local Learning Management System (LMS) may serve as a feasible strategic option for schools, particularly those with restricted access to global platforms. A Learning Management System tailored to student requirements and Problem-Based Learning syntax may improve interactivity, accessibility, and flexibility in education—three essential components of digital learning (Moore et al., 2011).

Moreover, e-learning components such as interactive videos, e-LKPD, quizzes, and discussion forums have shown efficacy in promoting active student engagement in critical thinking, analysis, and problem-solving. This corresponds with the empirical outcomes of pupils achieving high scores in critical thinking and PBL syntax. Problem-based learning is acknowledged for its efficacy in cultivating higher-order thinking abilities, as it necessitates students to engage in profound information analysis and make judgements based on evidence (Yew & Goh, 2016).

This PBL-based static fluid e-learning package effectively blends content, pedagogy, and technology. The elevated validity and practicality outcomes demonstrate that this media development fulfils students' requirements while also functioning as an innovative educational solution consistent with current advancements and the stipulations of the Merdeka Curriculum, which prioritises differentiated and competency-based learning (Hamzah et al., 2022).

CONCLUSION AND SUGGESTIONS

The expert validity assessment of the media, content, technological elements, and pedagogy found the constructed e-learning program to be valid. The practicality assessment conducted by instructors and students determined that the designed e-learning software is very practical. This research concludes that the Problem-Based Learning e-learning platform for enhancing students' critical thinking abilities in static fluid content is valid and practical. The designed e-learning module is suitable for application in Grade 11 high schools and madrasahs for the study of static fluids. Based on the findings of the e-learning development, the researcher recommends using a premium e-learning platform to access the capabilities provided by the LMS and advises more studies, including experimental studies.

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