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Design of Website-Based Learning Media to Enhance Critical Thinking Skills in Static Fluid Concepts

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Abstract. Critical thinking skills are one of the 21st-century skills that students must have, and the rapid development of technology provides a demand to develop a learning medium that facilitates this. Therefore, the purpose of this research is to create a website-based learning media design oriented to critical thinking skills on static fluid material. The research utilises the Successive Approximation Model (SAM) for its development. The research model consists of a preparation phase, an iterative design phase, and a final phase. The preparation phase is the initial stage to efficiently collect background information on the problem. The iterative design phase consists of design cycle activities, prototyping, and reviewing. The iterative design phase includes the process of developing, implementing, and evaluating learning media continuously. The research participants consisted of lecturers, prospective teachers, teachers, and students. The feasibility of the website was analysed in terms of material and media, which was conducted twice by six validators. In the first stage, the feasibility of the website in terms of material and media was declared "Feasible" with a V-aiken score of 0.600. After making improvements, the website was revalidated with a V-aiken score of 0.926 with the category "Feasible". Students' responses to the developed website were positive. The website's readability is excellent. This website-based learning media has contributed to meeting the demands of students' critical thinking skills.

Keyword: learning media, website, critical thinking

1. Introduction

The rapid development of Technology, Information, and Communication (ICT) in the 21st century has brought significant changes in the world of education [1]. One of the main skills demanded in this century is the ability to think critically, namely the ability to think rationally, logically, and reflectively in making decisions [2]. Critical thinking involves the activities of analyzing arguments, evaluating information, and drawing informed conclusions [3]. Therefore, the education system should lead to the development of higher-order thinking skills so that students can face complex global challenges [4].

However, the critical thinking skills of high school students in Indonesia are still relatively low based on the results of various studies [5]. In physics, many students have not been able to solve problems with high cognitive levels that require analysis and evaluation skills [6]. This is caused by learning that is still dominated by conventional methods such as lectures and practice questions without encouraging in-depth cognitive exploration [7]. In addition, teachers also have difficulty in designing learning strategies that can stimulate critical thinking skills due to limited training and innovative teaching materials [8]. This problem is even more complex because access to learning media that support critical thinking skills is still very limited [9].

On the other hand, most learners already own digital devices such as smartphones, tablets, and laptops [10]. However, the low level of digital literacy causes these devices not to be optimally utilized in learning [11]. In fact, digital literacy is important to support technology-based independent and critical learning [9]. This reality shows that although the potential for utilizing digital technology is quite large, its integration in the learning process to improve critical thinking skills is still not running optimally [12].

While students have access to digital devices and the internet, physics learning in the classroom has not optimized these technologies to build analytical and reflective thinking processes [10]. This shows that the potential of digital media in supporting the achievement of 21st century competencies has not been utilized systematically and pedagogically [11]. Students' understanding of stasis fluid material is only 18.8%, meaning that many students do not understand the material [13]. Physics books in Indonesia to support learning in the classroom still have low quality so that the development of quality learning media is needed [14]. In addition, there have not been many studies that specifically develop Web-based learning media designed to train students' critical thinking skills on conceptual physics topics such as Static Fluid [5].

Therefore, it is necessary to develop web-based learning media that not only utilizes available digital technology but is also pedagogically designed to develop students' critical thinking skills that meet the aspects of critical thinking, including the ability to analyze, evaluate, and draw conclusions based on relevant evidence [3]. Additionally, other experts add that critical thinking standards include clarity, accuracy, relevance, and logic, which should be reflected in students' reasoning [15]. By referring to these two models, the development of learning media needs to be adapted to encourage the formation of systematic and measurable critical thinking skills. Websites as interactive learning media are considered to increase student engagement, encourage independent learning, and provide access to a wider range of learning resources [9]. The TPACK framework is used as the basis for developing website-based learning media. This framework is the knowledge used to integrate technology, content, and pedagogy for learning. TPACK is divided into several aspects, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological knowledge (TK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) [16]. Therefore, this study aims to develop web-based learning media that focuses on developing critical thinking skills in the topic of Static Fluids as an alternative solution to improve the quality of physics education and support the achievement of 21st century competencies using the TPACK framework.

2. Method

This study uses a research and development method using the *Successive Approximation Model*. SAM is a development research model that has an iterative process to develop a product. SAM consists of three main stages, namely preparation phase, iterative design phase, and iterative development phase [17]. The stages of this research are described in Figure 1.

The research partisans consisted of physics education lecturers, physics education final year students, high school physics teachers, and high school grade XI students. Lecturers and physics teachers will validate the website-based learning media. Physics education students will provide criticism and suggestions through interviews. Eleventh grade high school students will respond to the website-based learning media through response questionnaires and fill in the overlap test questionnaire.

The first stage, the Preparation Phase, focuses on gathering information about physics learning needs, student characteristics, and existing opportunities and limitations. In this phase, the TPACK framework developed in previous research is also used as a reference to ensure that the learning media design aligns with the integration of technology, pedagogy, and physics content [18]. The second phase, the Iterative Design Phase, begins with designing web-based learning media, creating prototypes, and evaluating the media. These steps are repeated until optimal results are achieved. The third stage, the Iterative Development Phase, consists of developing alpha, beta, and gold versions. In the alpha version development, the prototype from the Iterative Design stage is developed into a product and tested on students, prospective teacher trainees, lecturers, and physics teachers. The validation of the content and media aspects is conducted by lecturers and physics teachers using the TPACK framework as a guideline to assess the integration of technology with pedagogical strategies and content [18]. Next, in the beta version development, the website-based learning media is refined based on feedback from the previous stage and retested by the same evaluators. Finally, in the gold version development, the refined product is tested on a limited basis with students to determine their responses and the readability of the website-based learning media.

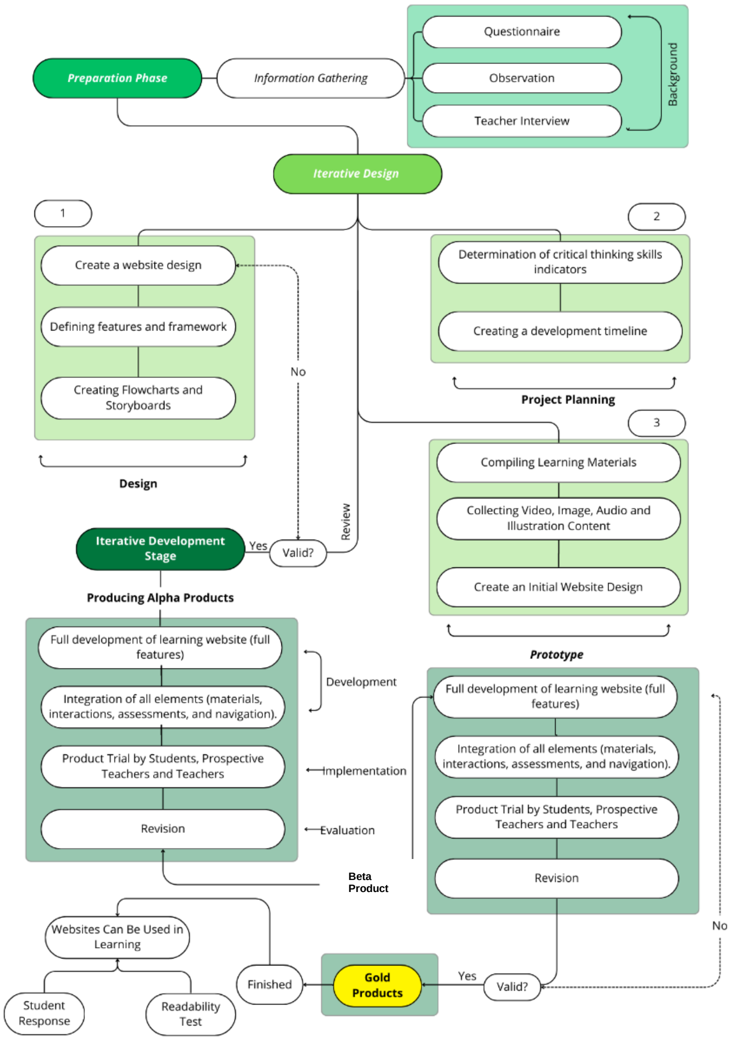


Figure 1. The flow of SAM research.

Web-based learning media based on material and media aspects will be validated by 6 experts with a scale of 5 "strongly agree" to a scale of 1 "strongly disagree". The results were analyzed using V-Aiken with the following formula:

$$V = \frac{\sum(r - l_o)}{[n(c-1)]} \tag{1}$$

where V is the Aiken coefficient, n is the number of validators, c is the number of rating scales, r is the value given by the validator, and l_0 is the smallest scale value. The V-Aiken coefficient is interpreted in Table 1.

Table 1. The aiken's validity criteria.

V-Aiken coefficient	Criteria
$0 \leq V \leq 0,4$	Low
$0,4 \leq V \leq 0,8$	Medium
$V \geq 0,8$	High

Student responses to web-based learning media with a scale of 5 "strongly agree" to a scale of 1 "strongly disagree". The results were analyzed using descriptive qualitative with the following formula:

$$\%respone = \frac{mean\ of\ score}{maximum\ score} \times 100\% \tag{2}$$

The response results are interpreted in Table 2.

Table 2. The student response criteria.

Response	Criteria
80% ≤ R ≤ 100%	Very good
60% ≤ R < 80%	Good
40% ≤ R < 60%	Good enough
20% ≤ R < 40%	Not good
1% ≤ R < 20%	Very Not good

The readability of the website-based learning media uses the overlap test by removing certain words then students are asked to fill it back in [19] The number of correct answers was analyzed using the following formula:

$$\%true\ answer = \frac{number\ of\ correct\ answers}{jnumber\ of\ question} \times 100\% \tag{3}$$

The readability results are interpreted in Table 3.

Table 3. The readability criteria.

Readability	Criteria
60% ≤ R ≤ 100%	Independent
40% ≤ R < 60%	Instructional
R < 40%	Difficult

3. Result and Discussion

This research aims to develop critical thinking skills-oriented Website-based learning media on Static Fluid material as an alternative solution to improve the quality of physics learning and support the achievement of 21st century competencies. This development uses the *Successive Approximation Model* (SAM) development which is explained as follows:

3.1. *Preparation Phase*

At this stage, a survey was conducted to 41 high school students regarding the need for website-based learning media oriented towards critical thinking skills in terms of habits of using digital media, learning preferences, and the need for website-based learning media that can encourage critical thinking skills. The results of the student needs analysis are presented in Table 4.

Based on Table 4 digital media access is sufficient for students to learn using web-based learning media and students have a considerable preference for learning using web-based learning media. Then in terms of needs, students also need learning media that helps in solving problems, visualizing concepts, and practicing higher order thinking skills. So, it can be concluded that the importance of developing *web-based* learning media that is interactive, easily accessible, and responsive to student needs. It not only supports student engagement, but also facilitates the understanding of complex physics concepts through visual and problem-based approaches. This finding is in line that visual and *multimedia* elements in science learning can improve learning effectiveness [20].

Table 4. The survey results of physics learning media needs.

Aspect	Sub-aspect	Percentage (%)
Digital Media Access	Smartphone availability	100
	Internet access	89
	Habitual learning using digital media	92
	Habitual learning through learning videos	96
Learning Preferences	Interest in websites as learning media	92
	Ease of understanding physics concepts through practical activities and visual simulations	85
	Interest in media that presents visualization of physics concepts and animation	91
Media Needs	The need for physics question exercises with higher order thinking skills	96
	Difficulty to connect physics concepts with real problems	84
	Difficulty answering deep analysis or decision-making questions	94
	The need for media that presents visualization of physics concepts and animation	89

3.2. *Iterative Design Phase*

Based on the previous stage, students have high enthusiasm and readiness to learn using a website that is responsive, interactive, and oriented towards developing critical thinking skills, especially on static fluid material. Web-based learning media with critical thinking skills orientation is designed based on critical thinking skills indicators [15].

Table 5. The student response results.

Critical Thinking Indicator	Description	Cognitive Aspect
Comparing information from various sources	Students' ability to gather, evaluate, and compare information from two or more different sources before completing a specific task.	Analyzing
Draw conclusions based on data or fact analysis	Students' ability to logically analyze relevant numbers, facts, or information and draw conclusions based on available evidence.	Evaluate
Summarize or interpret information read or studied	Students' ability to summarize or interpret material that has been read or taught using their own language in a logical manner.	Understanding
Analyzing conflicting arguments or solutions	Students' ability to assess various opinions, perspectives, or alternative solutions to problems and determine the strengths and weaknesses of each.	Analyzing
Develop convincing arguments based on evidence and reasoning	Students' ability to form strong and logical opinions or arguments supported by relevant evidence or reasons.	Creating
Solve complex problems that do not have one right answer	Students' ability to identify and solve complex problems with various approaches without relying on a single solution.	Create

Based on the critical thinking indicators used, it appears that the media is able to train abilities such as comparing information, analyzing arguments, concluding based on data, and solving complex problems. This is important because critical thinking is an essential competency of the 21st century and is demanded in science and technology-based learning [2] [4].

3.3. *Iterative Development Phase*

In the *Iterative Development Phase*, there are 3 versions of development including alpha, beta, and gold development. The results of each development phase are presented as follows:

3.3.1. *Alpa phase*

At the alpha stage, the learning media developed into a product will be validated by 6 experts from the fields of materials and media, and then tested by physics education students. Material validation refers to the quality of content/material, alignment of learning objectives, feedback and adaptation, and motivation [21]. In addition, learning media are also validated from the aspect of critical thinking skills consisting of analyzing, evaluating, and solving problems [15]. The following feasibility results at the alpha stage are presented in Table 6.

Table 6. The alpha stage material validation results.

Aspect	V-aiken coefficient	Criteria
Content quality	0,500	Medium
Alignment of learning objectives	0,573	Medium
Feedback and adaptation	0,458	Medium
Motivation	0,542	Medium
Critical thinking skills	0,583	Medium

Media validation refers to interaction design, interaction usability, accessibility, and compliance standards. The results of media validation are presented in Table 7.

Table 7. The alpa stage media validation results.

Aspect	V-aiken coefficient	Criteria
Interaction design	0,646	Medium
Interaction usability	0,653	Medium
Accessibility	0,667	Medium
Staffing standard	0,708	Medium

User feedback on the web-based learning media is presented in Table 8.

Table 8. The user feedback alpa stage.

Aspect	Feedback	Improvement
Content/ Material	Material presentation and learning activities are separated	Material presentation and learning activities are separated so that students focus more on learning activities
	Conceptual expressions are given references/citations	Every expression has been given a citation
	Provide physical illustrations for each formula	Provide illustrations for each formula so that students are more interested
	Material does not need to use levelization	Access to learning materials can move from one learning step to another.
	Include videos of phenomena in life	In the learning steps, videos of phenomena have been added
Media	Font style using website standard	Style fonts use titles, subtitles, and content
	Fix equation on the website	Fixed equation using LaTex plugin
	Improve the website to be more reposnsive	Website has been tested with ui.dev.

3.3.2. *Beta Stage*

In the beta stage, the improved learning media is tested again to the same physics education lecturer and physics teacher to validate the product in terms of material and media. While physics education students and students will give interviews about the products developed. The results of the material validation at the beta stage are presented in Table 9.

Table 9. The beta stage material validation results.

Aspect	V-akien coefficient	Criteria
Content quality	0,917	High
Alignment of learning objectives	0,938	High
Feedback and adaptation	0,792	Medium
Motivation	0,958	High
Critical thinking skills	0,958	High

The results of the validation of web-based learning media from the media aspect are presented in Table 10.

Table 10. The beta stage media validation results.

Aspect	V-akien coefficient	Criteria
Interaction design	0,917	High
Interaction usability	0,903	High
Accessibility	0,938	High
Standard of care	1,000	High

The results of the feasibility test from physics education lecturers and physics teachers at the beta stage have better results than the feasibility at the alpha stage with improvements according to input from validators and other users. This improvement reflects the effectiveness of the iterative approach to the SAM development model in improving products based on user input. The SAM model that prioritizes iterative evaluation has proven to be effective and able to produce more relevant and quality products [13]. In the beta stage, users also provided feedback on the website-based learning media presented in Table 11.

Table 11. The beta stage user feedback.

Aspect	Feedback	Improvement
Material	Improvements to the arrangement of the material so that each learning step has indicators of critical thinking skills.	The material is organized using the PBL learning model. Each learning step has indicators of critical thinking skills
Media	The website usage guide is incomplete	The website usage guide is completed starting from how to register until students complete the learning.
	Developer section, add supervisor	Add a profile of the supervisor along with a google scholar account
	Chatbot for instant answer guide there is a menu that overlaps with the floating button to up menu	Chatbot for instant answer guide has been moved from the right to the left so that features do not overlap and errors occur when on the lesson or material page.
	In the login and register feature there is a bug, when logging in there should be no register button.	The login feature has been fixed, where when logging in, the register button on the menu above will not exist.

3.3.3. Gold Stage

The gold stage is the final phase in the process of developing web-based learning media, where the product has gone through the revision stage from the alpha and beta results. At this stage, the media is tested on a limited basis to 20 students to test the overall end-user response, as well as assess the readability level of the developed media content. The results of student responses to web-based learning media are presented in Table 12.

Table 12. The student response to website-based learning media.

Aspect	Sub-aspect	Percentage (%)	Criteria
Student Participation	Student participation in learning	91	Very good
	Activeness to ask questions and discussion	88	Very good
	Student engagement in learning	91	Very good
	Student interest in the website	88	Very good
	Students' motivation to learn	90	Very good
	Students' enthusiasm for learning	94	Very good
Material / Content	The material is easy to learn	72	Good
	New concepts are easy to understand through the website	72	Good
	Comfort to learn through the website	71	Good
Presentation of Material	Visualization (pictures, colors, animations)	74	Good
	Menu arrangement and navigation	71	Good
	Website appearance is attractive and pleasing to the eye	85	Very good
	Combination of color, font, and layout	91	Very good
	Images, illustrations, or videos	95	Very good
	The layout of information in this media is neat	92	Very good
	Animation or transition	90	Very good
	Visualization in media	96	Very good
	Website is easily accessible anywhere and anytime	94	Very good
	Access to media is fast and not confusing	97	Very good

Students' responses showed a very high level of participation and interest in the developed media, especially in the aspects of visualization, navigation, and interactivity. This finding supports that the integration of visual elements and animation in web-based media can increase student engagement and understanding of abstract concepts [20]. The readability of critical thinking skills-oriented web-based learning media is presented in Table 13.

Table 13. The readability of web-based learning media.

Readability (%)	Criteria
91,7	Independent

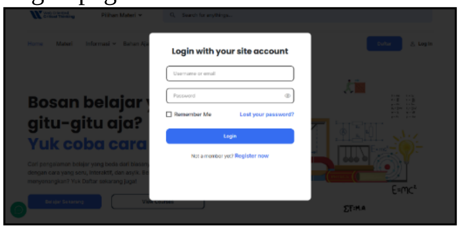
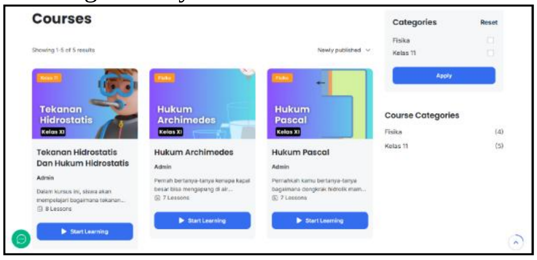
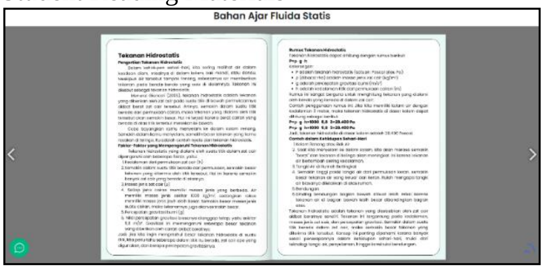
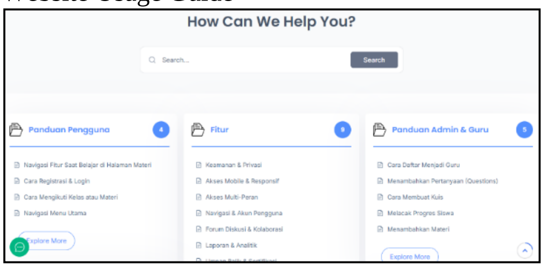
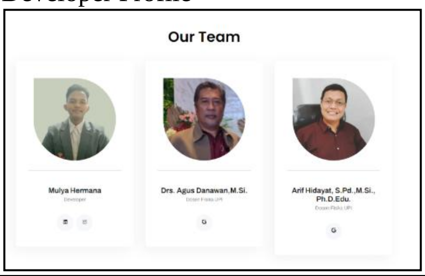
Based on Table 13, the readability of website-based learning media oriented to critical thinking skills has a readability score of 91.7%, meaning that students are able to understand the contents of the media without additional assistance. This shows that the text structure, language use, and visual presentation in the media are in accordance with the cognitive characteristics of students. In this context, readability is an important factor in encouraging independent and reflective learning [19].

The final result of the development of web-based learning media oriented towards the development of critical thinking skills can be accessed via the following link https://Wothink.my.id.

Table 14. The final results of website-based learning media.

Website Component	Description
Home Page 	• Header: Displays the logo and main navigation for easy access to the main features. • Images: Illustrative visuals to attract attention and reinforce the context of the material. • Materials: Presents a selection of learning materials on static fluids • Image and login button: Supporting illustrations with a button to log in to the user account. • Footer: Contains additional information such as contact, copyright, and other important links.

<table>
<tr><th>Website Component</th><th>Description</th></tr>
<tr><td>Account Registration

</td><td>Registration is one of the requirements to access learning on the website.
Registration data includes: username, email, password, and repeat password.
All student data will be entered into the server database in the admin dashboard</td></tr>
<tr><td>Log in page

</td><td>The login page displays an area to fill in the username and password to be able to enter and access the learning website.
The login and register pages are made pop up to make it easier to login to the website.</td></tr>
<tr><td>Learning Activity

</td><td>Displays a number of topics on Hydrostatic Pressure, Archimedes' Law, and Static Fluid Phenomena.
Each topic is displayed in a card layout format with class information, free status, and a Start Learning button for quick access.
Navigation between materials is supported by a carousel or slider feature, providing a more dynamic and user-friendly user experience.</td></tr>
<tr><td>Student Reading Materials

</td><td>The reading section contains materials that students can access to support learning activities.
Reading material is presented in a flipbook feature
The material consists of: Hydrostatic Pressure, Archimedes' Law, and Static Fluid Phenomena.</td></tr>
<tr><td>Website Usage Guide

</td><td>The user guide includes: feature navigation, how to register, how to join the class, and menu navigation.
Features: security & privacy, mobile & responsive access, multi-role access, navigation & accounts, discussion & collaboration forums, reports & analytics, feedback etc.
Admin & Teacher Guides: how to register as a teacher, add questions, how to create quizzes, track student progress, add materials</td></tr>
<tr><td>Developer Profile

</td><td>This section contains the website developer profile
Profile includes social media and google scholar</td></tr>
</table>

This website-based learning media is designed not only to deliver static fluid material, but also to train students' critical thinking skills through interactive content. Features such as physics phenomenon simulations, problem-based quizzes, concept exploration videos, and online discussion forums allow students to engage in problem-based learning. In addition, critical thinking requires the application of intellectual standards such as clarity, relevance, logic, and depth of understanding. This website integrates these elements through activities that ask students to compare information, draw conclusions from experimental data, and consider various solutions to complex physical problems [22]. Through this approach, students are directed to engage in the upper cognitive levels of Bloom's Taxonomy, such as analyzing, evaluating, and creating. These activities directly support the critical thinking indicators used in this study.

The results of this study are in line with previous research that problem-based learning in physics learning can significantly improve students' critical thinking skills. This approach combines digital and face-to-face learning with problem-solving strategies, so that students are actively involved in analyzing information, evaluating solutions, and drawing conclusions based on experimental data [22]. It is also supported that critical thinking skills can develop rapidly when learners are involved in problem-based digital making activities. This activity not only stimulates reflective thinking, but also contributes to the strengthening of four other 21st century skills, namely collaboration, communication, and creativity [23]. In addition, it is also supported by previous research that the application of problem-based learning models in static fluid material significantly improves students' critical and creative thinking skills. This indicates that problem-based learning packaged digitally and visually is very relevant to use in conceptual and abstract physics topics, such as fluids [24]. Thus, the results of this study reinforce previous findings that website-based learning media that integrate problem-based learning approaches and interactive features have great potential in improving students' critical thinking skills as a whole.

4. Conclusions

The development of website-based learning media with critical thinking skills orientation on static fluid material was successfully implemented. The final feasibility of the website in terms of material has a score of 0.931 in the "high" category and the final feasibility in terms of media has a score of 0.939 in the "high" category. Students' responses to the website-based learning media have positive responses in terms of student participation, material/content, and material presentation. In addition, the readability of website-based learning media has a percentage of 91.7% which means students can read independently. Website-based learning media on static fluid material have contributed to providing a variety of learning media in achieving critical thinking skills in physics lessons.

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