

Development of Interactive Web Learning Media Based on Problem-Based Learning on the Topic of Work Energy and Simple Machines for Junior High School Students

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Abstract: The rapid development of digital technology in education requires innovative learning media to support students' problem-solving skills in science learning. This study aims to develop an interactive web learning media based on problem-based learning on the topic of work, energy, and simple machines for junior high school students. This research employed a Research and Development (R&D) approach using the ADDIE model, focusing solely on the development stage. The data were collected using validation questionnaires (content, media, and language) and practicality questionnaires for teachers and students. The validation data were analyzed using the Gregory validity coefficient, while the practicality data were analyzed using descriptive statistical analysis. The validity test was conducted by two experts in content, media, and language relevant to their respective fields. The practicality test involved three science teachers and twelve students of SMP Negeri 1 Seririt. The results showed that the KVG for content validity was 0.95, while the media and language validity reached 1.00, both categorized as very high validity. The teacher's practicality score was 100, and the student's practicality score was 44.66, both categorized as very practical. These findings indicate that the developed interactive web-based learning media is valid and practical, and has the potential to support the development of students' problem-solving skills in learning the concepts of work, energy, and simple machines.

Keywords: Interactive Web Learning Media; Practicality; Problem-Based Learning; Validity.

Introduction

The development of 21st-century learning demands instructional practices that are no longer solely oriented toward content delivery, but rather toward the development of higher-order thinking skills [1]. In the current educational context, science learning is directed at fostering critical thinking, collaboration, creativity, and communication skills as essential competencies for students in facing global challenges. Science education is not only focused on conceptual mastery but must also be balanced with students' ability to relate scientific knowledge to real-world problems, thereby making learning more meaningful and applicable [2].

21st-century learning is also characterised by the use of digital technology to support the learning process. The development of digital technology has become an important strategy for realising more interactive and meaningful science learning. The transformation towards Society 5.0 places technology as a supporting tool in education to create adaptive learning that is oriented towards the needs of students [3]. The use of Technology Enhanced Learning (TEL) enables the visualisation of abstract science concepts through digital simulations, animations, and interactive platforms that can help students build a deeper conceptual understanding [4]. The use of technology has been shown to encourage active student engagement in analysis and problem-solving [5], [6]. The use of digital technology is also one of the focuses in the implementation

of the Merdeka Curriculum, which encourages more flexible and student-centred learning [7].

Despite various efforts to transform learning, including the integration of educational technology into the Merdeka Curriculum, improvements in the quality of science learning have not been fully reflected in student achievement. The results of the Programme for International Student Assessment (PISA) in 2022 indicate that Indonesia's science abilities remain at level 1a, which signifies mastery limited to simple scientific phenomena and basic cause-and-effect relationships. At this level, students are not yet able to construct hypotheses, predict complex phenomena, and critically evaluate the limitations of scientific data [8]. This low level of science literacy indicates that basic problem-solving skills, which include conceptual understanding, reasoning, and evidence-based decision-making, are also at a low level [9].

The use of non-interactive learning media and the dominance of conventional learning methods are factors that hinder the optimization of students' learning potential. A preliminary study at SMP N 1 Seririt reinforce these findings, as learning tends to rely solely on printed textbooks and PowerPoint presentations. Initial findings in several junior high schools also show that the use of interactive learning media is still limited, and learning still tends to be teacher-centered [10], [11]. As a result, the learning environment becomes less challenging, insufficient to facilitate students' ability to explore and investigate concepts directly, and hinders the development of students' problem-solving skills [12], [13].

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These learning problems are particularly evident in the topics of work, energy, and simple machines. Findings from schools obtained through student questionnaires indicate significant difficulties, especially in the sub-topics of work and energy calculations and the application of simple machine principles in real-life contexts. This difficulty indicates that students still tend to focus on memorizing formulas, resulting in suboptimal conceptual understanding and the ability to relate scientific concepts to real-life situations. This condition is in line with previous research findings, which show that students who perceive physics learning as a memorization process tend to use superficial learning strategies characterized by low learning engagement and minimal conceptual understanding. [14]. This learning orientation can result in students having a low ability to understand concepts in depth and apply them in problem-solving contexts. Therefore, it is necessary to implement more context- and problem-based learning to comprehensively address students' comprehension difficulties.

The application of problem-based learning models is a strategic effort to overcome the obstacles students face. This learning model begins the learning process with contextual problems and plays a role in students' developing their analytical, evaluative, and problem-solving skills through scientific processes [15], [16]. However, to facilitate this learning model, Innovative learning media are essential to effectively support every stage of the learning process. Therefore, interactive web-based learning media is presented as a solution to digitize the stages of problem-based learning, so that the exploration of concepts of matter, energy, and simple machines is no longer limited to the physical classroom. Through this web platform, real-world problems will be presented as instructional starting points, integrated with interactive features such as visual simulations and educational videos.

Although web-based media development has been widely pursued, most previous studies have focused on descriptive material, such as the reproductive and circulatory systems. [17], [18]. Meanwhile, topics such as work, energy, and simple machines, which are often considered abstract and involve extensive mathematical calculations, require more dynamic learning media. However, previous studies have not explicitly integrated the syntax of Problem-Based Learning (PBL) into interactive web-based media, particularly for abstract physics topics. This study is conducted to address this shortcoming by integrating visual simulations and interactive quizzes into a Google Sites platform specifically designed to follow the syntax of problem-based learning. Therefore, this study offers novelty by combining PBL syntax with interactive web-based media supported by visual simulations and problem-oriented activities to enhance students' problem-solving skills. Through this approach, real-world problems are not only presented in textual form but also visualized to support students in developing problem-solving skills.

Accordingly, this study aims to develop an interactive web-based learning media based on Problem-Based Learning that is valid and practical for use in science learning on the topic of work, energy, and simple machines.

Research Methods

This study utilized a Research and Development (R&D) design, following the stages of Analysis, Design, Development, Implementation, and Evaluation, which are part of the ADDIE model. However, the study was limited to the Development stage, as its primary objective was to produce a valid and practical product before proceeding to broader implementation and effectiveness testing. The subjects of this study were selected using a purposive sampling technique, in which participants were chosen based on specific criteria relevant to the research objectives. The subjects consisted of two expert validators who were selected based on their expertise in science content, instructional media, and language, three science teachers who teach Grade VIII, and 12 eighth-grade students of SMP Negeri 1 Seririt, academic year 2025/2026, who were categorized into low, medium, and high academic ability levels based on their previous science achievement scores.

The selection of 12 students was intended to represent initial user responses in a limited-scale trial, which is appropriate in the development stage to identify practicality and usability issues before large-scale implementation. This study was conducted in Grade VIII of SMP Negeri 1 Seririt, located at Jl. Udayana No. 25 A, Seririt, Buleleng, Bali. The procedural flow of the media development using the ADDIE model is presented in Figure 1.

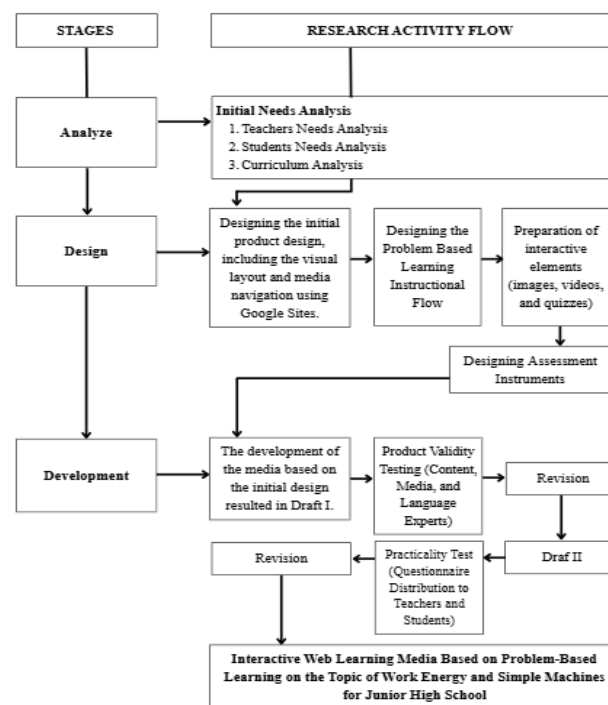


Figure 1. Flow of Media Development Procedures

This study focuses on evaluating two main aspects, namely validity and practicality. The validity test was carried out by two experts in the field of science education. The assessment was carried out using questionnaires administered to experts to evaluate the relevance of the web-based learning media. The data obtained from the experts' evaluations were mapped into a 2x2 cross-tabulation matrix, as shown in Table 1.

Table 1. 2x2 Cross Tabulation Matrix

2x2 Cross Tabulation		Judge I	
		Low Validity	High Validity
Judge I	Low Validity	A	B
	High Validity	C	D

[18]

$$KVG = \frac{D}{A + B + C + D}$$

Description:

- KVG = Gregory Validity Coefficient
- A = the number of items rated as less valid by two judges
- B = number of items assessed as less valid by Judge I and highly valid by Judge II
- C = number of items assessed as highly valid by Judge I and less valid by Judge II
- D = the number of items rated as very valid by two judges

The results were then used to construct a qualification assessment table to determine the level of validity of the developed product. The validity assessment qualifications are presented in Table 2.

Table 2. Validity Assessment Qualification

Score Interval	Category
0.81 – 1.00	Very High Validity
0.61 – 0.80	High Validity
0.31 – 0.60	Moderate Validity
0.21 – 0.30	Low Validity
0.00 – 0.20	Very Low Validity

[18]

The practicality test was conducted by involving 12 eighth-grade students and 3 science teachers at SMP N 1 Seririt. This assessment was conducted by distributing questionnaires using a circular scale with a rating interval of 1-5, as shown in Table 3.

Table 3. Likert Scale Guidelines

Score	Description
1	Very Poor
2	Poor
3	Sufficiently
4	Good
5	Very Good

[19]

Next, the scores obtained will be analyzed using the following formula.

$$\bar{X} = \frac{\sum x}{N}$$

Description:

- \bar{X} = mean score of each component
- $\sum x$ = total score
- N = number of indicators assessed

The obtained mean scores were converted to qualitative values by first calculating M_i and SD_i to determine the interval criteria for the practicality assessment. The formula for determining the interval criteria of the practicality assessment is provided in Table 4. Based on the calculation results, the obtained M_i value was 60, and the SD_i was 13.3 for teacher practicality. Meanwhile, for student

practicality, the M_i value was 30, and the SD_i was 6.7. These scores were then used to determine the interval criteria in assessing teacher and student practicality, as presented in Tables 5 and 6.

Table 4. Practicality Assessment Score Interval

Score Interval	Category
$M_i + 1.5 SD_i < X$	Very Practical
$M_i + 0.5 SD_i < X \leq M_i + 1.5 SD_i$	Practical
$M_i - 0.5 SD_i < X \leq M_i + 0.5 SD_i$	Moderately Practical
$M_i - 1.5 SD_i < X \leq M_i - 0.5 SD_i$	Less Practical
$X \leq M_i - 1.5 SD_i$	Not Practical

[20]

Description:

- X = Respondent's Score
- M_i = Ideal Mean
- SD_i = Ideal Standard Deviation
- $M_i = \frac{1}{2} (\text{highest ideal score} + \text{lowest ideal score})$
- $SD_i = \frac{1}{6} (\text{highest ideal score} - \text{lowest ideal score})$

Table 5. Teacher Practicality Assessment Criteria Interval

Score Interval	Category
$79.95 < X$	Very Practical
$66.65 < X \leq 79.95$	Practical
$53.35 < X \leq 66.65$	Moderately Practical
$40.05 < X \leq 53.35$	Less Practical
$X \leq 40.05$	Not Practical

Table 6. Student Practicality Assessment Criteria Interval

Score Interval	Category
$40.05 < X$	Very Practical
$33.35 < X \leq 40.05$	Practical
$26.65 < X \leq 33.35$	Moderately Practical
$19.95 < X \leq 26.65$	Less Practical
$X \leq 19.95$	Not Practical

Results and Discussion

Based on the implemented ADDIE Model, the results and discussion for each stage are as follows.

Analysis Stage

The analysis stage aims to identify fundamental problems and the needs for media development in the field. This stage encompasses three main aspects, namely teacher needs analysis, student needs analysis, and curriculum analysis. Based on the teacher needs analysis questionnaire, 70% of the dominant learning media used include images or illustrations from printed books, PowerPoint presentations, educational videos, and 40% on teaching aids. The instructional models implemented are also varied. Although both media and instructional models have been varied, teachers still face difficulties in designing learning activities that encourage independent concept discovery and in stimulating students to formulate appropriate contextual problems, particularly on topics such as work, energy, and simple machines. This aligns with the questionnaire results, which showed that 100% of teachers reported that the most difficult material to teach was formulas and calculations related to work and energy.

This condition indicates that the currently available media are not sufficiently functional to support innovative instructional models. The existing media tend to be one-way and informative; they have not facilitated active student engagement in a systematic problem-solving process. Therefore, it is necessary to develop learning media that can integrate the syntax of the problem-based learning (PBL) model. This media is designed to overcome teachers' limitations by providing problem scenarios and facilitating structured student concept discovery. This is in line with the view of [21], the effectiveness of problem-based learning (PBL) depends on the quality of instructional planning and implementation, particularly in presenting authentic problems, facilitating the discussion process, and providing appropriate scaffolding for students.

A similar gap was also identified in the students' needs analysis, where students' learning interests were not proportional to their level of conceptual understanding. The data indicate that the dominant use of whiteboard media and images in printed textbooks has not adequately supported learning, as 75% of students reported that the media were not optimal for facilitating their understanding of the material. Although students show interest in science learning, the high cognitive load associated with memorizing formulas and the perception of the material as abstract indicate that instruction remains theoretical in nature and continues to be teacher-centered, primarily relying on lecture-based methods. The condition also poses a risk of low conceptual understanding among students, which ultimately leads to superficial understanding (surface learning) that is less meaningful. [22]. Students also expect interactive learning media equipped with videos, quizzes, and self-directed exploration features to help them understand concepts more concretely.

The curriculum analysis also reinforces this need by referring to the Science Learning Outcomes (Capaian Pembelajaran IPA) for Phase D of the Merdeka Curriculum, which emphasize the understanding of the concepts of Work, Energy, and Simple Machines [23]. The conceptual and mathematical nature of the material requires learning that goes beyond mastering formulas to include contextual problem-solving skills. Therefore, the development of interactive learning media based on problem-based learning serves as a strategic solution to bridge students' needs with curriculum demands and support more meaningful learning. The web-based format is also selected for its advantages in presenting flexible multimedia content, facilitating independent access to learning materials without spatial constraints, and enabling the integration of interactive features essential to supporting the stages of problem-based learning (PBL).

Design Stage

The design stage aims to develop the initial structure, format, and content of the learning media before proceeding to the subsequent development stage. The media design was based on the results of the prior needs analysis, and the selected medium was a web-based platform using Google Sites. The selection of this platform is based on its ease of access, flexibility in integrating various multimedia content, ability to support independent learning, and capacity to enhance student engagement interactively [24], [25]. The initial design of the media was systematically developed by

integrating the five syntactic stages of problem-based learning into the menu structure, particularly in the student worksheet section. The media structure includes the home menu, instructions, learning outcomes and objectives, contextual materials, student worksheets, and reflection and evaluation features. The visual elements of the media were enhanced with Canva for header design and supporting illustrations, while videos were integrated via YouTube to support the audiovisual presentation of the material.

The interactive web-based format is designed to support digital learning integrated within a single platform. The utilization of PhET simulations in virtual experimental activities and the use of Liveworksheets in student worksheets enable students to directly explore concepts and receive feedback. In addition, learning evaluation is supported by various game-based platforms, such as Wordwall, Zep, and CrosswordLabs, which help increase students' motivation to learn. The learning materials are developed in reference to the Science Learning Outcomes of Phase D and are presented in a contextualised format through problems closely related to everyday life. The alignment of the materials with curriculum standards is an important aspect to ensure that the media is not only visually engaging but also pedagogically functional in supporting the achievement of students' competencies [26].

As part of product quality assurance, assessment instruments were developed at the design stage. The instruments included validation sheets for content/material experts, media and language experts, and practicality instruments for teachers and students. The assessment focused on the appropriateness of the material, clarity of language, quality of media presentation, and alignment of the media with the PBL syntax. The development of the instruments was guided by the principles of content validity and indicator clarity to produce accurate and objective evaluations. The use of standardized assessment instruments is an essential aspect of research and development to ensure the theoretical and practical feasibility of the product.

Development Stage

The development stage is a continuation of the design stage, aimed at realizing the initial design of the problem-based learning-oriented interactive science web-based learning media into a complete and ready-to-use product. At this stage, all components designed in the design phase are implemented in an integrated web-based learning media using the Google Sites platform. The developed web-based media includes a comprehensive menu structure comprising user guidelines for teachers and students, learning outcomes and objectives, Student Worksheets, instructional materials, reflection and evaluation, an author profile, and references. Each menu is functionally designed to support the implementation of the PBL syntax on the topic of work, energy, and simple machines. The systematic arrangement of menus ensures that the learning flow proceeds intuitively, allowing students to move easily from one menu to another. The uniqueness of the developed media lies in the explicit integration of Problem-Based Learning (PBL) syntax into the web-based platform, particularly within the student worksheet, which systematically guides students through problem orientation, investigation, and reflection stages. In addition, the integration of simulations, interactive quizzes,

and contextual real-life problems distinguishes this media from conventional web-based learning media that primarily focus on content delivery. After the entire media development process was completed, the web-based media was then published so that it could be accessed online through the following link: <https://sites.google.com/view/usahaenergidanpesawatsederhana/home>. Several main interface displays of the developed media are presented in the following figure.

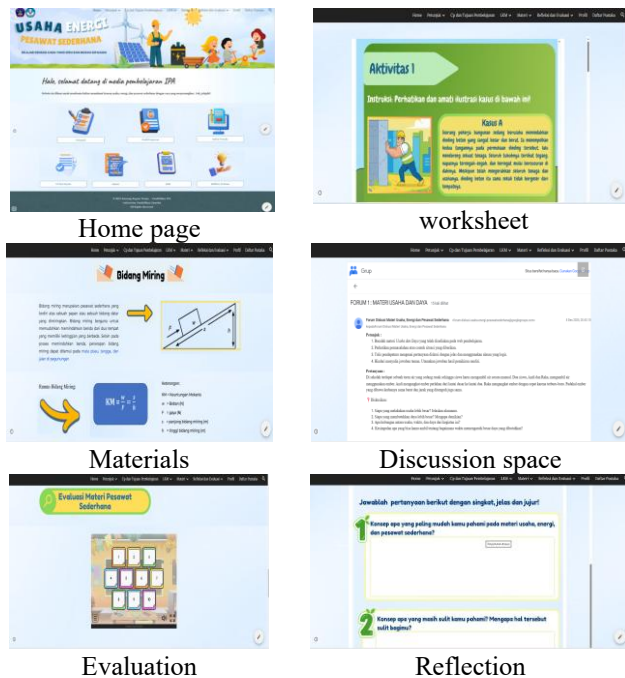


Figure 2. Web Media Display

Validity of Interactive Web Media Based on Problem-Based Learning

Product feasibility was measured through a validation test conducted by two experts in Science Education. The validation covered two main aspects, namely content validity and media and language validity. The results of the assessment are presented in the following table.

Table 7. Content/Material Expert Validity Results

Validator		Judge I	
		Low Validity	High Validity
Judge II	Low Validity	0	0
	High Validity	1	21
Gregory's Validity Coefficient		0.95	
Category		Very High Validity	

Table 8. Media and Language Expert Validity Results

Validator		Judge I	
		Low Validity	High Validity
Judge II	Low Validity	0	0
	High Validity	0	23
Gregory's Validity Coefficient		1.00	
Category		Very High Validity	

Based on the calculation results, a content validity score of 0.95 was obtained, categorized as very high validity, indicating that the material is relevant to the Merdeka Curriculum, conceptually accurate, and aligned with the syntax of problem-based learning. The experts' feedback served as an important basis for product refinement. Major revisions were made to the development of the example questions, which were redesigned as contextual, problem-based questions presented as real-life scenarios requiring analysis and solutions based on learned concepts. In addition, a summary of the material was added to reinforce the student worksheet (LKM), the presentation was modified into a narrative problem situation, without direct questions, to encourage students to first understand the problem's context.

The results of content validity indicate that the presentation of material in the developed web-based media meets the characteristics of learning media content, being systematically and structurally organised while integrating verbal and visual elements cohesively. The material presentation is supported by clear explanatory text, relevant images and illustrations, and supplementary videos that clarify the concepts. This aligns with the principles of the Cognitive Theory of Multimedia Learning (CTML) proposed by Mayer, which emphasizes that material should be presented through a combination of verbal elements in the form of explanatory text and visual elements in the form of illustrative images, as well as relevant displays to clarify concepts [27]. Presenting information verbally and visually simultaneously allows students to receive information through two different cognitive channels, thereby enhancing conceptual understanding and reducing cognitive load [27]. In addition, the material is organized progressively from simpler concepts to more complex ones, accompanied by explanations and a summary of the learning. The systematic organization of learning materials allows students to follow the learning sequence in a more directed manner. As stated in the study [28], presenting materials in a structured way can facilitate and accelerate the learning process because students receive information in a sequential and organized manner.

The media and language validity obtained an average score of 1.00, categorized as very high validity, indicating that the media meets feasibility standards in terms of visuals, usability, and language readability. The media was considered responsive, easily accessible, and designed with a layout that supports user comfort. Feedback from media and language experts focused on optimizing the media's appearance. Revisions were made by integrating learning videos directly into the material, so students can access audiovisual resources without having to navigate to another menu. In addition, the font type and size adjustments were revised to enhance readability and maintain display consistency.

The results of media and language validity indicate that the media possess interactive characteristics through the provision of immediate feedback features and the systematic presentation of information. The presence of these interactive features allows students to receive direct feedback on their answers, thereby facilitating independent concept clarification. In addition, the media offer clear navigation, a consistent layout, and flexible access, as they

can be used anywhere, anytime on various devices, such as computers, smartphones, and laptops. These characteristics support student engagement without significant technical barriers. This aligns with [29], which states that the characteristics of interactive learning media include flexibility, customisation, and interactivity, which support students' active engagement in learning. Thus, the developed media not only meet high validity standards but also facilitate learning.

The Practicality of Interactive Web Media Based on Problem-Based Learning (PBL)

The product's practicality was tested by teachers and students to determine the level of practicality of the developed web-based learning media. The results of the practicality assessment conducted by teachers at SMP N 1 Seririt are presented in Table 9.

Table 9. Practicality Assessment by Teachers

No	Total Items	Total Score	Category
1	20	100	Very Practical

Based on the results of the teacher practicality test, an average score of 100 was obtained, categorized as very practical. This result indicates that the web-based media is considered very easy to use. Teachers assessed that the media navigation is clear and does not make it difficult to access the menus. The ease of accessing media across different devices was also considered to facilitate teachers' learning management without requiring additional application installation.

From a pedagogical perspective, web-based media is considered capable of assisting teachers in orienting students toward contextual problems and facilitating learning stages in accordance with the syntax of problem-based learning. These findings are consistent with previous research [30], which states that learning media serve as tools for delivering instructional content and stimulating student engagement in the learning process. In addition, the layout, proportional color combinations, and the use of relevant icons and illustrations make the media comfortable to use in learning. This indicates that the media have fulfilled the characteristics of good media, capable of functioning as a communication and interaction aid between teachers and students [31]. The data from students' practicality assessment are shown in Table 10.

Table 10. Practicality Assessment by Students

No	Total Items	Total Score	Category
1	10	44.66	Very Practical

In the practicality test, students obtained an average score of 44.66, placing them in the very practical category. Although the teacher obtained a score of 100 and the students obtained a score of 44.66, both are categorized as "very practical" because the interval classification is based on each instrument's ideal score range. Since the number of questionnaire items for teachers and students differs, the maximum, minimum, and interval boundaries also differ proportionally. Therefore, the categorization refers to the relative position of the obtained score within its respective ideal range, not to the absolute numerical value. This score

indicates that the media is easy to use. In terms of language, students stated it is easy to understand, concise, and appropriate to their level of comprehension, thereby facilitating independent learning. Regarding the presentation of learning, students assessed that the learning objectives were clearly communicated and that the learning activities presented in the Student Worksheet (LKM) helped them understand everyday-life problems. From the media appearance aspect, students gave positive evaluations regarding the choice and size of fonts, color composition, as well as the attractiveness of the images and videos presented. The appealing appearance was considered to make learning less monotonous. This is in line with the function of learning media, which can help students understand the meaning of the material more concretely and reduce verbalistic-based learning [32]. In addition, the media's layout structure and navigation were considered easy to follow and not confusing, allowing students to move between menus smoothly.

Overall, the results of content validity, media and language validity, and teacher and student practicality consistently indicate that the developed media fall into the "very valid" and "very practical" categories. Thus, the developed media not only meet high validity standards but also demonstrate high practicality in supporting the learning process. Although this study did not directly measure learning effectiveness as a dependent variable, the characteristics of the developed media indicate their potential impact on students' conceptual understanding and problem-solving skills. The integration of PBL syntax through contextual problem orientation and guided investigation enables students to actively construct knowledge and engage in systematic problem-solving processes, as Problem-Based Learning emphasizes structured problem-solving activities and promotes critical thinking and solution development [33]. In addition, the use of interactive features such as simulations and immediate feedback allows students to explore concepts more deeply, which may reduce misconceptions and support meaningful learning.

The present study is consistent with prior research on the development of interactive media, which generally reports high levels of validity and practicality. However, this study makes a distinctive contribution by integrating the syntax of problem-based learning into a structured web-based platform, thereby offering a more systematic approach to facilitating students' problem-solving processes than similar R&D studies.

Despite these positive results, this study has several limitations: it focused only on the development stage, did not test learning effectiveness in real classroom settings, and involved only a few validators and respondents. In addition, implementing this media may face challenges such as limited internet access, varying levels of students' digital literacy, and the need for teacher readiness in applying problem-based learning. Therefore, teacher readiness and adequate technological infrastructure are important factors in supporting the optimal use of this media in schools.

Conclusion

This study demonstrates that the developed interactive web-based learning media that was developed has fulfilled the requirements of high validity and practicality.

Validity is assessed by content, media, and language experts, while practicality is determined from teachers' and students' responses. Therefore, the developed media can be utilized as an alternative resource to support science instruction at the junior high school level. For teachers, this web-based learning media can be utilized as an alternative learning tool that supports problem-based learning and creates an active and engaging learning process. In addition, the integration of problem-based learning in the media has the potential to improve students' problem-solving skills by encouraging them to analyze real-life problems, construct their own understanding, and develop critical thinking abilities. For students, this web-based learning media can serve as a supporting resource for the topics of work, energy, and simple machines. Through interactive features and problem-oriented activities, students are expected to achieve better learning outcomes, particularly in understanding concepts and applying them in everyday contexts. Meanwhile, for future researchers, it is recommended to conduct an effectiveness test of the developed problem-based learning web media to determine its impact on learning.

Author's Contribution

K. R. Triana: contributed to the development of the learning media, conducted the research, and performed data analysis. N. Erlina: provided guidance and support throughout the research process, as well as reviewed the manuscript. P. Sarini: contributed to the writing and revision of the manuscript to enhance its quality.

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