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Developing Web-Enhanced Physics Learning Media on Renewable Energy Using Google Sites

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Abstract: Education in Indonesia requires the utilization of technology to improve the quality of learning. The Web-Enhanced Course (WEC) model offers flexibility in accessing learning materials while supporting the effectiveness of face-to-face instruction. Google Sites serves as a relevant medium, integrating text, video, and interactive features that foster students' motivation and engagement. This study aims to develop physics learning media based on the Web Enhanced Course model using Google Sites, focusing on renewable energy topics, to evaluate its feasibility and assess students' responses in grade X of senior high schools. This research employed a development method adapted from the Borg and Gall model, which consists of seven stages. Data collection instruments included expert validation sheets for media and material, as well as student response questionnaires. Data were analyzed using descriptive statistical analysis to determine the level of feasibility and attractiveness of the developed media. The results indicated that the physics learning media based on WEC, with the aid of Google Sites, were highly feasible, with material expert validation reaching 85% and media expert validation at 86%. The small-group trial obtained 89%, and the field trial achieved 90%, both categorized as very interesting. Educators and students responded positively to the media in terms of ease of use, material relevance, and engaging presentation. The media has the potential to enhance students' conceptual understanding of renewable energy and strengthen the integration of digital technology in physics learning. More broadly, this study contributes to the development of 21st-century learning models that are collaborative, interactive, and grounded in digital literacy. Further research is recommended to examine the effectiveness of this media on other physics topics and in diverse educational contexts.

Keywords: Google Sites; Learning Media; Web-Enhanced Course.

Introduction

Education is an essential part of human life, as it provides opportunities for individuals to improve their quality of life while achieving their desired goals [1]. In Indonesia, efforts to enhance the quality of national education continue in order to produce highly qualified human resources, in line with technological advancements and globalization [2][3][4]. The utilization of technology, particularly the internet, has led to the emergence of various innovative learning media that facilitate the learning process, including interactive media that combine visuals, audio, and simulations to help students understand concepts [5]. The integration of such advanced educational strategies can improve learning effectiveness, as the quality of education depends not only on the media used but also on the roles of educators, the curriculum, students, and the learning environment [6][7]. In the digital era, the use of media and electronic devices is crucial for capturing students' interest and enhancing their understanding [8].

The development of science, technology, and communication has greatly supported the creation of learning media. Various interactive learning media have been designed and implemented in many schools and educational institutions. Experimental activities can now be conducted through interactive simulation media, enabling students to participate in virtual practicum sessions. Computer technology can also be utilized to support physics practicum, ranging from understanding concepts, collecting data, to presenting and processing data more effectively [9]. In addition, students who are able to manage their own learning process tend to be more active and engaged, as they can adapt the learning experience to their individual abilities [10][11].

Learning media plays a crucial role as a bridge between teachers and students, delivering material in an engaging and easily understandable way. It can be utilized at all levels of education to enhance interest, motivation, and the achievement of learning objectives. In addition, media supports teachers in delivering material more effectively [12][13]. Educational technology, or instructional technology, is an applied field that aims to solve various problems in the learning process [14]. Learning media clarifies the delivery of material, encourages teachers' creativity, attracts students' enthusiasm, and creates an enjoyable learning environment [15]. With the advancement of the digital era, teachers are required to design learning that aligns with technology, one of which is interactive media that can be accessed anytime and anywhere [16].

Web-based learning offers advantages such as fast access and the freedom for students to obtain information without being limited by space and time [17]. One of its applications is the Web Enhanced Course (WEC), which combines face-to-face learning with internet support,

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allowing students to access learning materials more flexibly [18]. Google Sites is a platform that can be utilized in WEC. This application facilitates the creation of interactive websites by integrating text, images, and videos, making learning more effective and engaging [19][20]. Google Sites also promotes collaboration, creativity, and optimal use of study times [21][22]. According to Herdini et al., their study demonstrated that learning media developed using Google Sites achieved an "excellent" category, as evaluated by subject matter experts and media experts, with an average score of 97.21% [23].

Previous studies have developed learning media using Google Sites to support various subjects. The use of digital content through Google Sites has been shown to enhance students' digital literacy and support self-directed learning [24], other studies demonstrated that websites developed with Google Sites can increase students' learning interest, particularly in social studies [25]. In the field of physics, Google Sites has been applied to support the learning of Newton's Laws, Momentum, and Impulse, effectively improving students' engagement and conceptual understanding [26][27].

Unlike previous studies, this research focuses on developing Web Enhanced Course (WEC)-based physics learning media using Google Sites on the topic of Renewable Energy. The selection of this topic is grounded in the global urgency of the energy crisis, the need for sustainable education, and the national curriculum's demand to equip students with knowledge of environmentally friendly energy sources. Digital interactive media addressing renewable energy concepts in secondary schools remains very limited, which makes it difficult for students to fully comprehend these concepts [28][29][30]. The novelty of this study lies in the integration of renewable energy concepts with the WEC approach through Google Sites, which not only presents content interactively and flexibly but also supports sustainable education by promoting a deep and participatory understanding of concepts [31].

Based on a preliminary study conducted through questionnaires and interviews with subject teachers at SMAN 10 and SMA Al-Azhar 3 Bandar Lampung, it was found that most students still rely on printed textbooks as their primary learning media, while the use of interactive digital media, particularly web-based platforms, remains very limited. Students often struggle to comprehend physics concepts, including renewable energy, solely through textbooks, resulting in low engagement in the learning process. These findings highlight the importance of developing Web-Enhanced Course-Based learning media using Google Sites, which is more engaging, flexible, interactive, and aligned with the characteristics of modern learning. With this media, students can access materials flexibly, learn more actively, gain a better understanding of renewable energy concepts, and be motivated to improve their learning outcomes.

Based on the issues described above, this study aims to develop and evaluate the feasibility of Web-Enhanced Course-Based physics learning media using Google Sites on the topic of renewable energy, as well as to assess user responses to its implementation. This research seeks to address the gap in the limited use of digital technology in physics learning by introducing an innovative integration of an interactive web platform that supports independent, engaging, and relevant learning aligned with students' needs in the digital era.

Research Methods

Research and Development (R&D) was the method used in this investigation. The goal of this approach was to utilise Google Sites to create a learning media product based on a Web Enhanced Course and to determine how physics teachers and students responded to the product on renewable energy for senior high school students in Grade X.

This study adopted the Borg and Gall development model, which consists of ten systematic stages in educational research and development. However, due to time and budget constraints, the study was limited to the first seven stages. The research involved 120 participants, including physics educators and tenth-grade students from SMAN 10 Bandar Lampung and SMA Al-Azhar 3 Bandar Lampung [32].

The end result is a web-based learning tool that both educators and learners can use to enhance physics instruction and help meet learning goals [33]. Research that creates or develops a particular product through multiple expert evaluations, including material validation, design validation, small-group product trials, and field trials to assess the developed product's attractiveness, is included in this model. These development steps align with current educational research and development. Ten development steps are needed in this study to create a finished product that can be used in educational settings. However, the study was limited to the first seven steps due to time and budgetary constraints. A Google Sites-based educational resource on renewable energy is the end result of this development investigation.

Questionnaires, observation sheets, interview sheets, material expert evaluation sheets, and media expert assessment sheets were among the tools utilised in this investigation. Before being distributed, the instruments were validated by experts to ensure content validity and reliability. Data analysis was conducted to assess the feasibility of the developed Web Enhanced Course learning media, and the results provided the basis for refining the media.

Techniques for descriptive data analysis were used in this development study. The findings of the feasibility evaluation were assessed using descriptive analysis, which computed the average score. Two categories were used to classify the research data: qualitative data, in the form of descriptive responses, and quantitative data, in the form of numerical scores. While quantitative data were analyzed using descriptive averages, qualitative data were analyzed rationally and meaningfully. For Grade X students at SMAN 10 Bandar Lampung and SMA Al-Azhar 3 Bandar Lampung, the results of the descriptive analysis were utilized to assess the feasibility of the Web Enhanced Course-based physics learning materials on renewable energy utilizing Google Sites.

Expert reviews, including assessments by material and media specialists, were used to determine the viability of web-enhanced, course-based physics learning materials developed using Google Sites. It was anticipated that this method would make the data easier to understand for subsequent processes. The generated media package was revised based on the analysis of the data results. Descriptive statistics were used to analyse opinions or answers to the product that were gathered through questionnaires. A Likert

scale was used in the questionnaire-based non-test tool. The Likert scale is used to gauge an individual's or a group's attitudes, beliefs, and perceptions about a social phenomenon or event (Sudaryono et al., 2013). A scale of 1 to 5 was employed in this investigation, where 1 represented the lowest score and 5 the highest. Therefore, the following formula can be used to determine the overall assessment score [34]:

$$\%SS = \frac{\overline{SS}}{S_m} \times 100\%$$

Description:
SS =Average Score
$S_{m=}$Maximum Score

The criteria for interpreting the percentage intervals of expert validation on media feasibility are presented in the table below.

Table 1. Percentage Interval of Expert Feasibility Validation Assessment

Interval	Assessment Criteria
$> 84\%$	Very Feasible
$69\% < \overline{x} \leq 84\%$	Feasible
$52\% < \overline{x} \leq 69\%$	Moderately Feasible
$36\% < \overline{x} \leq 52\%$	Not Feasible
$< 36\%$	Highly Infeasible

The following Table 2 presents the percentage results of the product trial conducted with students.

Table 2. Percentage Interval of Student Response Assessment

Interval	Assessment Criteria
$> 84\%$	Very Interesting
$69\% < \overline{x} \leq 84\%$	Interesting
$52\% < \overline{x} \leq 69\%$	Moderately Interesting
$36\% < \overline{x} \leq 52\%$	Not Interesting
$< 36\%$	Very Uninteresting

Since the research focus was limited to the product feasibility stage, instrument reliability testing was not conducted in this study. To determine the mean score and percentage of feasibility for the Web Enhanced Course-based learning materials using Google Sites on the subject of renewable energy, the instruments, which included expert validation questionnaires and student response questionnaires, were examined using descriptive statistics [35].

Results and Discussion

Potential and Problems

Teachers still mostly employ traditional media, such as textbooks and student worksheets, in physics lessons, according to the analysis of potentials and difficulties. The lack of creativity in the learning process, resulting from the restricted range of media, has made it less successful in holding students' attention. According to Sadiman, learning media are various instruments that teachers can use to communicate with students, pique their interest, and stimulate their thoughts, feelings, and attention, thereby facilitating learning. Accordingly, Rahmani's research demonstrates that incorporating media into physics instruction can enhance student engagement and motivate active learning.

Data Collection

Based on the information obtained, the schools where the research was conducted had not fully implemented physics learning using web-based media, and no innovative learning media were available that could integrate materials into a unified learning framework. In reality, the curriculum places a strong emphasis on the value of contextual learning, inspiring pupils to address real-world problems and think critically and creatively. This method provides students with the opportunity to thoroughly examine ideas through real-world learning experiences in the context of physics study, both individually and in groups. For example, students can study phenomena related to renewable energy from various physics perspectives, including energy concepts, the law of conservation of energy, and the effects of its use in daily life.

Product Design

The next phase involved using Google Sites to create Web-enhanced course-based learning materials. At this point, several tasks were completed, one of which was creating a flowchart that would illustrate the programme's structure. After enrolling for an account on Google Sites, the developer produced the required resources, including instructional materials and supplementary files in the form of pictures, animations, and videos.

The web-based learning media consists of several main menus: Home, Information, Materials, Example Problems, Practice Questions, PhET Simulation, and Visual Questions, the latter featuring images designed to stimulate creative thinking. The first menu, Home, functions as the main page and can be accessed directly by users. This page displays the website banner and navigation buttons that link to the four main available features. The interface of the Home menu is presented in Figure 1.

Figure 1. Home Menu Display

The next menu is Information, which contains the learning outcomes and learning objectives. This section provides an overview of the competencies that students are expected to achieve, acquire, and master upon completing

the learning activities. Through this menu, students are not only informed about the direction and targets of learning from the outset, but also guided to develop an awareness of the skills, knowledge, and attitudes they should cultivate during the process. Additionally, the Information menu serves as a reference point for both students and educators, ensuring that every activity, material, and assessment is aligned with the predetermined outcomes. By having this clear framework, students can better prepare themselves, set personal goals, and monitor their own progress throughout the course. The display of the Information menu is shown in Figure 2.

Figure 2. The Display of the Information Menu

The Materials menu contains discussions on the topic of renewable energy, enriched with animations, images, and videos to help students understand concepts more easily. In this menu, there are selectable buttons according to the subject matter students wish to study, providing flexibility in accessing the content. The web-based presentation makes the material more varied and engaging, while the displayed animations simplify complex information into a clearer and more understandable form. In addition, each topic is also accompanied by instructional videos that visualize energy concepts, ensuring that dynamic content can be delivered more effectively [36]. The Materials menu is displayed in Figure 3.

Figure 3. Display of the Materials Menu

The Example Questions menu contains questions and explanations related to the topic of renewable energy. Each question is accompanied by supporting images to help students better understand the concepts being studied. The presentation of these example questions not only provides an overview of how the material is applied but also trains students' analytical and problem-solving skills. The display of the Example Questions menu is shown in Figure 4.

Figure 4. Display of the Example Questions Menu

The PhET Simulation menu enables students to conduct virtual experiments on renewable energy and energy transformations, providing practical instructions, student worksheets, and a report submission button. The addition of this virtual simulation menu enables students to collaboratively discover concepts with the aid of student worksheets. This menu facilitates experiment design with ease of operation and time efficiency [37]. The Simulation menu display is shown in Figure 5.

Figure 5. Display of the PhET Simulation Menu

Design Validation and Revision

The design validation stage was conducted to assess the feasibility of the product design, specifically in the form of Web-Enhanced Course-Based learning media utilising Google Sites to support physics learning on the topic of

renewable energy. Validation was conducted by media experts and subject matter experts. The media experts consisted of three lecturers as validators. Data were collected using an evaluation instrument sheet covering aspects of Google Sites display design, content design, and ease of use, along with feedback and suggestions for improving the learning media. The validation results from the three media experts are presented in Figure 6.

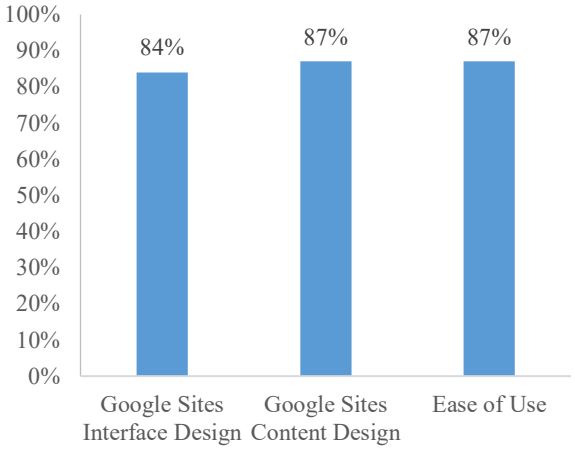

Figure 6. Media Validation Results

Based on the results of the media expert validation analysis shown in Figure 6, an overall percentage of 86% was obtained, categorized as "Highly Feasible." The assessment was conducted on three main aspects, namely Google Sites display design, content design, and ease of use. Among these aspects, content design received the highest score with a percentage of 87%, indicating that the media content was considered highly relevant, systematic, and aligned with the objectives of physics learning. The presentation of the material was complemented with images, illustrations, and integration of other media to optimally support students' understanding. The ease-of-use aspect also received a score of 87%, indicating that the media can be easily accessed through a simple web address, features clear navigation menus, and provides efficient features that enable both students and teachers to use it without significant technical difficulties. Meanwhile, the display design aspect scored 84%, which, although slightly lower than the other two aspects, still fell into the "Highly Feasible" category. This indicates that the media display was sufficiently attractive and interactive, with layout, color selection, and typography supporting readability, though there is still room for improvement to make it more varied and visually consistent. Overall, with an average percentage of 86%, the Google Sites-based learning media developed was considered highly feasible for effectively supporting the physics learning process, as it met the criteria of content, accessibility, and design quality.

Subsequently, validation was carried out by material experts consisting of three lecturers with expertise in physics. Data were collected using an assessment instrument sheet that included aspects of content feasibility, presentation feasibility, and language feasibility, accompanied by feedback and suggestions for improving the learning media. The validation results from the three material experts are presented in Figure 7.

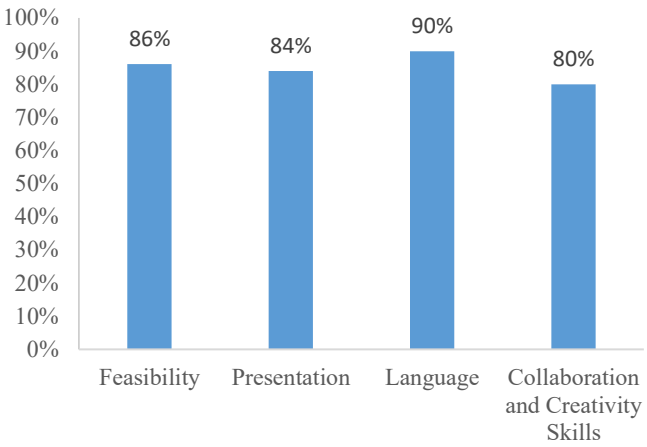

Figure 7. Content Validation Results

With the help of Google Sites, the Web Enhanced Course-based physics learning materials achieved an average percentage of 85% with the category "Highly Feasible," according to the analytical results of the material expert validation shown in Figure 7. Four primary criteria—content feasibility, presentation feasibility, language feasibility, and collaborative and creative skills—were used to conduct the assessment. The medium received an 86% rating for content feasibility, indicating that the created content aligns with the learning objectives for physics, covers pertinent subject matter, and is supported by appropriate and accurate examples. The presented physics concepts were considered scientifically correct and consistent, accompanied by sufficient references that strengthen the reliability of the content. Furthermore, the presentation's feasibility aspect obtained a percentage of 84%, showing that the topics were arranged systematically, clearly, and in accordance with learning objectives. This allows students to follow the material sequence more easily and to engage in independent learning through the developed media. Meanwhile, the language feasibility aspect achieved the highest score with 90%, meaning that the language used in the media is highly communicative, simple, and easy to understand for students. Clear wording and consistent terminology support the effectiveness of material delivery while minimizing misconceptions. In the collaborative and creative skills aspect, the media obtained a percentage of 80%, indicating that it has facilitated students in practising teamwork, thinking creatively, and developing ideas during the learning process, although there is still room for improvement to achieve optimal results. Thus, the results of material expert validation show that the Google Sites-based physics learning media meet the feasibility standards in terms of content, presentation, language, as well as collaborative and creative skills, making it highly feasible to be used in supporting effective and independent learning [38].

All aspects received very good evaluations from the experts; however, the researcher still made minor revisions to further improve the quality of the learning media. Based on suggestions from material experts, revisions included aligning the content more closely with the curriculum to better match learning outcomes, adding examples and practice questions to strengthen concept comprehension, and refining learning objectives and outcomes to make them clearer and more measurable. Additionally, the completeness

of the material was enhanced by incorporating relevant supporting references. From the perspective of the media experts, revisions focused on the design aspects, such as improving font selection for greater consistency, adjusting colors to enhance readability, and refining images and videos to make them more engaging and aligned with the material context. With these revisions, the Web-enhanced course-based learning media through Google Sites is expected to create a more interactive and engaging learning experience that effectively supports students' understanding.

Product Trial and Product Revision

The product trial was conducted to assess students' interest in and responses to the Web-enhanced course-based learning media using Google Sites. The purpose was to obtain information from students regarding the developed media so that it could be refined in line with the researcher's expectations. The trial was carried out in two stages: a small-group trial and a field trial. The small-group trial aimed to identify initial problems that might arise during the use of the media, while the field trial aimed to determine the overall weaknesses of the product. A simple random sampling technique was employed, as the students were considered homogeneous in nature. In the small-group trial, response questionnaires were completed by Grade X Science students, with each school selecting 5 students as samples. The questionnaire assessed aspects of material presentation, language, and the usefulness of the learning media for students.

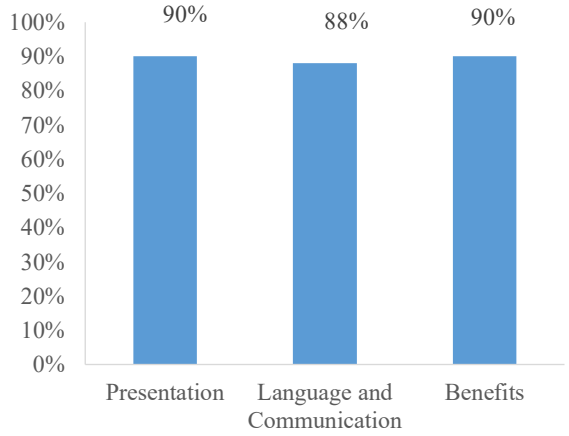

Figure 8. Small Group Trial Results

Based on the results of the small-group trial, the Google Sites learning media achieved scores of 90% for the presentation aspect, 88% for the language and communication aspect, and 90% for the usefulness aspect, with an average of 89%, which falls into the "very interesting" category. The high score in the presentation aspect indicates that the material was presented in a systematic, clear, and easy-to-follow manner for students. The 88% score in the language and communication aspect shows that the language used was communicative, easy to understand, and appropriate to the students' level of development, although a few minor improvements were suggested. Meanwhile, the usefulness aspect, which obtained a score of 90%, reflects that students found the media beneficial in helping them understand the material, increasing their motivation, and supporting independent learning.

The small-group trial was conducted prior to the field trial, allowing the researcher to identify potential technical or content-related issues in the media and to obtain an initial overview of student responses to the developed media. The positive responses from students at this stage served as an important foundation for making minor revisions, thereby ensuring that the media became more ready, engaging, and aligned with students' needs before being implemented in the field trial with a larger number of participants.

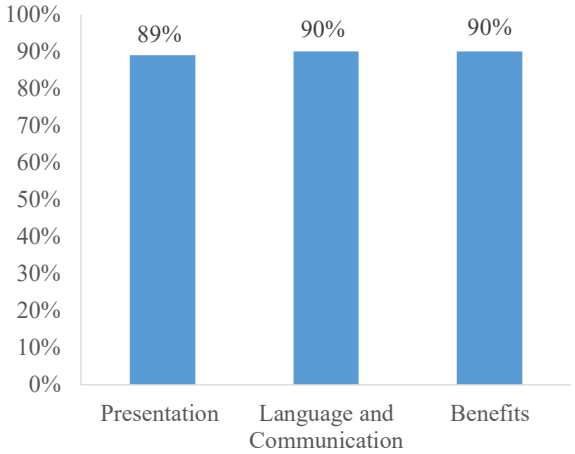

Figura 9. Field Trial Results

According to the findings of the Google Sites learning media field testing, the presentation component received an 89% score, the language and communication component received a 90% score, and the usefulness of the media product for students also achieved a 90% score. The field trial findings fell into the "very interesting" category with an average percentage of 90%. Therefore, it was determined that the Web-enhanced course-based learning materials created with Google Sites were viable and appropriate for use as a supplementary resource in physics education, specifically with regard to the subject of renewable energy. Product revisions were made based on feedback and suggestions provided through the student response questionnaire, indicating that students were highly enthusiastic about the product, gave positive responses, and supported the use of Web–enhanced course-based physics learning media developed with Google Sites.

Web-enhanced course-based learning media, with the help of Google Sites, provide benefits for both students and educators. In line with the study by Ali Mustofa et al. (2020), the use of web-based media creates a new atmosphere in learning, helps prevent boredom, and makes the learning process more enjoyable [39] . This encourages students' learning motivation while making it easier for them to understand the material. Additionally, Google Sites is easily accessible, enabling students to review previously learned material as a form of evaluation. For educators, this media facilitates the delivery of information, the presentation of materials, and the distribution of learning resources, as all content is integrated into a single website. Thus, the material is presented more effectively, attractively, and is less likely to become cluttered or lost [40].

According to this study, several organised procedures were involved in creating Web-Enhanced Course-Based learning materials using Google Sites. Using questionnaires

and observations, the initial stage was to determine the potentials and issues that occurred at SMAN 10 Bandar Lampung and SMA Al Azhar 3 Bandar Lampung. The study found that the majority of students had internet connections to facilitate online learning and were already accustomed to using digital devices, such as laptops and smartphones. However, the findings demonstrated that traditional teaching strategies, such as lectures and PowerPoint presentations, continued to dominate physics education, which reduced student engagement and caused them to lose interest quickly. This condition highlights the need for innovative technology-based learning media that not only provide materials in an engaging and interactive manner but also enhance students' understanding of physics concepts, particularly in the context of renewable energy.

The validation process of the Web–enhanced course-based learning media, with the aid of Google Sites, involved three media experts and three subject matter experts. The validators used a Likert scale–based evaluation instrument to assess the feasibility of the design, content quality, and ease of use of the media. The validation results showed an average score of 86% from the media experts and 87% from the subject matter experts, placing the media in the "highly feasible" category for use in learning without requiring major revisions. The validators gave particularly high ratings to aspects such as site visualization design, systematic material presentation, and the alignment of content with the physics curriculum on renewable energy. From the user perspective, both teachers and students also gave positive responses, stating that the media was easy to use, engaging, and in line with current learning needs. These findings are consistent with constructivist learning theory, which emphasizes that teaching materials based on active and interactive exploration can enhance students' understanding in a more meaningful way.

The study's findings demonstrate that both professionals and students gave the physics learning resources on renewable energy, which were based on a Web-enhanced course using Google Sites, extremely high ratings. These positive reviews attest to the developed media's perceived value, applicability, and alignment with the requirements of education in the twenty-first century. This result aligns with a study by Septianti & Firdaus (2024), who created interactive media about sound waves using Google Sites. Material specialists assigned the study validation scores of 83%, while media experts assigned scores of 89.63%, both of which were considered "very valid." The results of the most recent study surpassed those of the previous one in comparison, particularly in terms of language, presentation, and media benefits. This difference may be attributed to the presentation of renewable energy materials, which were enriched with real-world contexts such as climate change issues and alternative energy sources, making it easier for students to understand abstract physics concepts [41].

The strong ratings this media received were a result of both design and student involvement. Similar findings were reported in a study by Firdaus Daud et al. (2024) on the usefulness of Google Sites media in the skeletal system topic, where students rated the media as useful, interesting, and easy to use. These similarities reinforce the argument that practicality and accessibility are key factors contributing to the high ratings given by students. Being web-based, the media can be accessed anytime and through various digital devices, offering a flexibility of learning that conventional methods cannot provide [42].

Furthermore, the high validation scores are also strongly linked to the relevance of the renewable energy topic itself. Renewable energy, which includes solar panels, wind energy, and biomass, is a global issue that is directly tied to everyday living. Students are more motivated to learn when they are encouraged to relate physics ideas to actual occurrences. According to a study by Lindra et al. (2025) on the creation of interactive materials for thermochemistry based on Google Sites, the' applicability of topics to real-world situations is crucial for raising student motivation and interest in learning. Thus, the success of the media in this study is not only determined by its technological features but also by the fact that the renewable energy topic is applicable, contextual, and capable of fostering students' awareness of global issues [43].

The two primary characteristics of the Technology Acceptance Model (TAM), which is a theory of technology-based learning, can be used to explain the study's findings: perceived utility and perceived ease of use. Because it successfully connected abstract ideas of renewable energy into more tangible representations through text, photos, and videos, the Google Sites-based media was seen as beneficial. Due to its straightforward layout and excellent accessibility, it was regarded as user-friendly at the time. A recent study by Ismail et al. (2023), which extended the TAM framework to the context of academic digital tools, also emphasized that usefulness and ease of use are the dominant factors influencing students' acceptance of technology-based media. This helps explain why the media in this study received very high scores, as both of these factors were successfully fulfilled [44].

In comparison to previous studies, this research makes a more specific contribution to the field of physics, with a focus on renewable energy. For instance, Septianti & Firdaus (2024) emphasized the aspect of project-based learning, while the present study highlights the integration of web-based tools (Google Sites) as a Web Enhanced Course that can be utilized both independently and collaboratively. Both studies reported high validation scores; however, the strength of this study lies in its choice of renewable energy as a topic, which aligns with global sustainable development issues and therefore offers broader relevance in both academic and social contexts. This demonstrates that the combination of visual design, accessibility, and content relevance to students' needs and current issues, along with its technological characteristics, is what makes Google Sites-based learning materials so successful.

According to the TAM paradigm, outside variables like system quality and content relevance also have an impact on how well learning media are accepted. The Google Sites-based content created for this study demonstrated excellent system quality, as it was consistently accessible on various devices, including PCs, tablets, and smartphones. Students' comfort and trust in utilising the media increased as a result of this consistency, which guaranteed that they could learn without any technical disruptions. Furthermore, the information felt practical and appropriate in real-world situations because it was directly related to the demands of the students with relation to renewable energy. In addition to meeting the requirements

of perceived utility and perceived simplicity of use, the combination of high-quality systems and pertinent material increased students' acceptance and motivation to make the most of the media.

Additionally, integrating learning about renewable energy through web-based media aligns with the Sustainable Development Goals (SDGs), namely Goal 13 (Climate Action) and Goal 7 (Affordable and Clean Energy). This suggests that, in addition to providing students with a cognitive understanding of physics, the educational process also helped them develop a critical awareness of the significance of transitioning to clean energy. Students responded more favourably when this global dimension was incorporated into the medium, increasing its instructional value. As a result, the high study scores demonstrate not only the technical features of the media but also its sustainability, social, and ecological relevance within the content of renewable energy [45].

Even when creating physics learning materials based on a Web-Enhanced Course on renewable energy using Google Sites has a lot of potential to improve students' comprehension and involvement, there are several advantages and disadvantages to consider. This media's capacity to contextualise the presentation of renewable energy concepts is one of its key advantages; it gives students more relevant and significant learning opportunities. Students can engage in activities that promote critical thinking, problem-solving, and teamwork thanks to Google Sites' interactive approach. Additionally, students can access the resources independently and flexibly due to the media's technological foundation, which meets the demands of learning in the digital age.

Nonetheless, it is important to recognise certain limitations. The fact that this Web-enhanced course was developed in just two schools limits the applicability of the findings to larger student populations. Furthermore, although the medium was successful in conveying concepts related to renewable energy, its application to other scientific issues has not yet been fully investigated. Further development is necessary to expand the range of physics content that can be integrated into web-based learning media. Another limitation is that the media have not directly assessed the impact on students' skills or attitudes within the context of renewable energy learning. Therefore, future studies are needed to evaluate the effects of implementing this media in more diverse educational settings.

Despite these limitations, the development of Web Enhanced Course media using Google Sites on renewable energy makes a meaningful contribution by providing instructional resources that bridge the gap between physics learning and students' awareness of clean energy and environmental sustainability. Although this study did not aim to measure effectiveness directly, the development process itself highlights the media's potential to cultivate students' awareness of renewable energy and the practical application of physics concepts in everyday life. By integrating environmental issues into physics learning, students are not only able to understand scientific concepts but also to develop critical thinking skills regarding the social and environmental impacts of energy utilization.

In addition, these findings indicate that the development of Google Sites–based Web Enhanced Course media can have a positive impact on students' learning outcomes. The media's interactive features and contextualized content help improve conceptual understanding, motivation, and learning engagement. Thus, the high validation and user response scores obtained in this study not only reflect the media's feasibility but also its potential effectiveness in enhancing physics learning achievement.

Conclusion

This study demonstrates that it is possible to incorporate physics learning materials on renewable energy into the classroom, based on a Web-Enhanced Course utilising Google Sites. Needs analysis, media design, expert validation, and teacher and student trials were key phases in the development process. Subject matter experts scored 85% and media experts scored 86% in the validation results, whilst small group and field trials scored 89% and 90%, respectively. Both students' and instructors' positive reactions indicate that the medium is pertinent, interesting, and well-suited for use in contemporary learning environments. This study successfully summarizes the development and validation of Google Sites–based learning media, highlighting its feasibility and relevance for 21st-century learning. This conclusion reflects the results and provides recommendations for future research regarding broader application and effectiveness testing. By offering clear implications for learning, it would be more valuable to explicitly state how this media can support specific competencies or learning objectives in physics education, such as improving conceptual understanding, collaboration, and problem-solving skills.

Author's Contribution

M. V. Agusta: developed the background, research methodology, results, and discussion. A. Asyhari: reviewed and provided corrections for the title and background. M.Mustari: reviewed and provided corrections for the research methodology, results, and discussion. All authors discussed their contributions to the final manuscript.

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