

Development of a Google Sites–Integrated Learning Management System (LMS) with Deep Learning to Support High School Students’ Understanding of Physics Concepts

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Submitted: 25/08/2026

Accepted: 29/08/2026

Published: 31/08/2026

Vol. 4

No. 2

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Abstrak- Physics learning requires digital media that are easily accessible and capable of helping students construct meaningful conceptual understanding. However, the use of e-learning in school physics instruction remains suboptimal. This study aimed to develop a Google Sites-based Learning Management System (LMS) integrated with deep learning principles to support Grade 10 students’ conceptual understanding of work and energy and to determine its validity and practicality. The study employed a Research and Development method using the Hannafin and Peck model. The needs analysis involved 22 students and 3 physics teachers. Product validation was conducted by experts, while practicality testing involved 20 high school students. The results showed that deep learning was identified as the highest need by both students (85.61%) and teachers (100.00%). The product achieved an average validity score of 85.14% (very valid) and a practicality score of 89.60% (very practical). Therefore, the developed LMS was considered feasible for use in Grade 10 physics learning to support students’ conceptual understanding of work and energy.

Keywords: *deep learning, Google Sites, Learning Management System, conceptual understanding, work and energy*

1 Introduction

Physics is a branch of science that examines various natural phenomena through concepts, principles, and laws that systematically explain the relationships among physical phenomena. Physics education is not merely intended to develop students’ mastery of mathematical formulas but also to foster their ability to understand physical concepts and apply them to explain phenomena encountered in everyday life. However, various studies have indicated that students’ conceptual understanding of physics remains relatively low. Students often experience difficulties in connecting the concepts they learn with real-world situations, resulting in learning that tends to emphasize the memorization of formulas rather than the development of deep conceptual understanding (Jufriadi et al., 2023; Purba et al., 2024). Consequently, students may develop misconceptions and encounter difficulties in solving contextual physics problems (Docktor & Mestre, 2014).

Advances in information technology have driven a shift in the learning paradigm toward more flexible, interactive, and student-centered learning environments. The integration of technology into education enables students to engage in more meaningful learning experiences by providing access to diverse digital learning resources that can be used anytime and anywhere (Bates, 2019). In physics education, digital media can facilitate the visualization of abstract concepts, making them easier for students to understand (Mayer,

How to Cite

Putri, T. L., Putri, S. A., Ningsih, R. R., Aden, & Rahmad, M. (2026). Development of a Google Sites–integrated learning management system (LMS) with deep learning to support high school students’ understanding of physics concepts. *Journal of Science, Learning Process and Instructional Research (JoSLEPI)*, 4(2). 53-64

2021). Therefore, there is a need for a learning environment capable of integrating instructional materials, simulations, learning videos, assessments, and reflective activities within a single structured learning environment.

One platform with considerable potential for use as a Learning Management System (LMS) is Google Sites. This platform enables teachers to develop digital learning environments without requiring advanced programming skills and can be accessed through various internet-connected devices (Ningsih & Bukit, 2022). Google Sites supports the integration of diverse learning resources, including instructional videos, virtual simulations, student worksheets, quizzes, and learning assessments, within a well-organized platform (Ismawati et al., 2021; Maharani et al., 2024). Its use has also been reported to improve students' motivation, learning outcomes, and engagement in the learning process (Amarulloh, 2022; Islanda & Darmawan, 2023). Although digital technologies offer various advantages for learning, their implementation needs to be pedagogically designed so that they do not merely function as tools for delivering information. One relevant pedagogical approach is deep learning. Deep learning emphasizes students' active engagement in constructing knowledge through exploration, reflection, problem-solving, and the connection of concepts with real-life experiences (Feriyanto & Anjariyah, 2024). Deep learning is oriented toward three fundamental principles: mindful, meaningful, and joyful learning. These principles are expected to enhance students' conceptual understanding, critical thinking skills, and learning autonomy (Fullan et al., 2018).

The preliminary needs analysis indicates that physics learning requires a digital learning environment capable of systematically integrating learning materials, learning activities, and assessments to support students' conceptual understanding. These findings provide the foundation for developing a Google Sites-based LMS integrated with deep learning principles. Based on the identified research gap, this study introduces an innovative Google Sites-based LMS integrated with deep learning principles through mindful, meaningful, and joyful learning activities. The proposed LMS integrates contextual phenomena, interactive simulations, scaffolded conceptual exercises, formative assessments, and learning reflection within a single structured digital environment to support high school students' conceptual understanding of work and energy. Accordingly, this study aims to develop a Google Sites based LMS integrated with deep learning to support high school students' conceptual understanding of physics and to determine its validity and practicality. The development and implementation of the LMS focus specifically on work and energy as the instructional context.

2. Research Methodology

This study employed a Research and Development (R&D) approach using the Hannafin and Peck (1988) development model. The model consists of three main stages: needs assessment, design, and development and implementation. According to Tegeh et al. (2014), development research is conducted through a series of systematic stages to produce educational products that meet the criteria of validity, practicality, and effectiveness. During the needs assessment stage, an analysis was conducted to identify existing learning conditions, student characteristics, teachers' needs, and challenges encountered in physics learning. The needs assessment involved 22 students and three physics teachers to obtain preliminary information regarding the need for developing a Google Sites based Learning Management System (LMS) integrated with deep learning principles. The design stage involved developing the flowchart, storyboard, LMS structure, learning materials, and research instruments.

Subsequently, the development and implementation stage involved developing the *Google Sites*-based LMS, conducting expert validation, revising the product, and carrying out trials with students. The LMS was designed and implemented for the topic of work and energy for Grade 10 senior high school students, which served as the physics content context for the product development process. Evaluation and revision were conducted continuously throughout each stage of the study to ensure that the resulting

product met users' needs and the established learning objectives. The Hannafin and Peck development model employed in this study is presented in Figure 1.

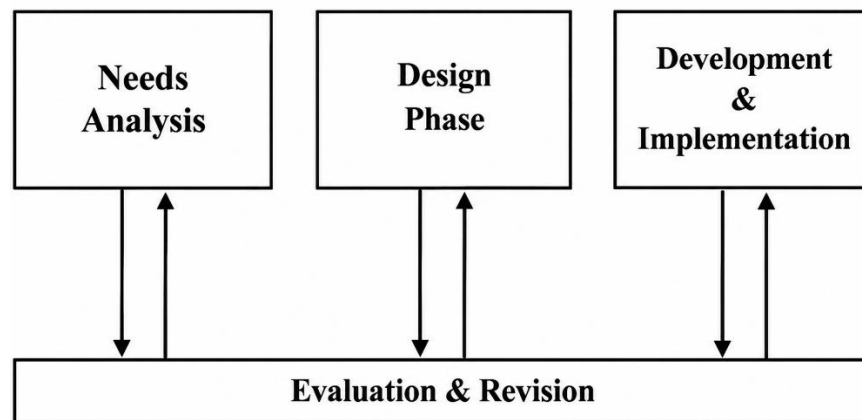


Figure 1. The Hannafin and Peck Development Model

Source: Adapted from Hannafin and Peck (1988)

Figure 1 illustrates the Hannafin and Peck model, which consists of three main stages: needs assessment, design, and development and implementation, accompanied by continuous evaluation and revision throughout the development process (Tegeh et al., 2014). The needs assessment data were collected using *Google Forms* on May 27, 2026. The respondents consisted of 22 students and three physics teachers. The needs assessment instruments for students and teachers comprised 15 closed-ended statements rated on a four-point Likert scale and three open-ended questions. The needs assessment aimed to obtain preliminary information regarding existing learning conditions and users' needs as a basis for product development. Therefore, the number of respondents was not intended to statistically represent the broader population but rather to identify initial needs and determine the direction of LMS development (Malina et al., 2021).

Prototype validation was conducted by two validators who were lecturers in Physics Education at Universitas Riau and had more than five years of experience in instructional media development and physics education. The involvement of two to three experts during the initial validation stage is commonly employed in development research to obtain feedback on content, media, and language aspects before the product is tested with its target users (Akbar, 2013; Sugiyono, 2019; Tegeh et al., 2014). The validation covered three aspects: content and pedagogy, media, and language. The content and pedagogical validation instrument consisted of 18 items, the media validation instrument comprised 18 items, and the language validation instrument consisted of eight items. All assessment items were rated using a five-point Likert scale. The percentages of user needs and product validity were calculated using Equation (1).

$$\text{Percentage} = \frac{\text{Obtained Score}}{\text{maximum ideal Score}} \times 100\% \quad (1)$$

The level of product validity was determined based on the interpretation criteria proposed by Akbar (2013). The validity categories used to interpret the results of the expert assessment are presented in Table 1.

Table 1. Product Validity Interpretation Criteria (Akbar, 2013)

Percentage (%)	Category	Interpretation
81,26 – 100,00	Highly Valid	Feasible to proceed with improvements based on the validators' recommendations.
62,51 – 81,25	Valid	Can proceed after minor revisions.
43,76 – 62,50	Less valid	Requires major revisions before field testing.
25,00 – 43,75	Invalid	Not yet feasible for use.

The practicality test was conducted with 20 senior high school students using a user response questionnaire consisting of 15 statement items covering ease of use, visual attractiveness, ease of navigation, clarity of learning materials, and the usefulness of the LMS in supporting the learning process. All items were rated using a five-point Likert scale. The practicality percentage was calculated using Equation (1), while the results were interpreted based on the criteria proposed by Akbar (2013).

3. Results and Discussion

3.1 Needs Assessment

The needs assessment stage was conducted to determine the direction for developing a *Google Sites*–based LMS integrated with deep learning principles. This analysis aimed to identify students' and teachers' needs regarding physics learning, the use of educational technology, the implementation of deep learning, and the LMS features required as a basis for designing the product.

The results of the student needs assessment indicated that all investigated aspects were categorized as needed to highly needed. The deep learning aspect obtained the highest percentage of need, indicating that students expected learning experiences that focused not only on the delivery of instructional content but also on providing mindful, meaningful, and joyful learning experiences. These findings indicate that students require an LMS that not only facilitates access to physics learning materials but also supports a more active and student-centered learning process. Detailed results of the student needs assessment for each aspect are presented in Table 2.

Table 2. Results of the Student Needs Assessment by Aspect

No.	Aspect	Obtained Score	Maximum Score	Percentage (%)	Interpretation
1	Physics Learning and Conceptual Understanding	230	352	65,34	Needed
2	Use of Educational Technology	213	264	80,68	Needed
3	Deep Learning	226	264	85,61	Highly Needed
4	Need for a <i>Google Sites</i> –Based LMS	356	440	80,91	Needed

Based on Table 2, the deep learning aspect obtained the highest percentage of need at 85.61%, followed by the need for a *Google Sites*–based LMS at 80.91%, the use of educational technology at 80.68%, and physics learning and conceptual understanding at 65.34%. These findings indicate that students not only require easily accessible digital learning media but also expect learning experiences that promote active engagement, conceptual exploration, and reflection on the learning process. These results are consistent with Feriyanto and Anjariyah (2024), who stated that deep learning is essential for fostering students' engagement, meaningful learning, and awareness in the learning process.

The students' responses to the open-ended questions revealed that the most frequently encountered difficulties were related to understanding physics concepts and applying formulas to solve

problems. This finding indicates that physics learning still tends to emphasize the application of formulas rather than the development of in-depth conceptual understanding. Therefore, the LMS was designed to facilitate the presentation of learning materials through contextual phenomena, concept visualizations, interactive simulations, scaffolded exercises, feedback, and learning reflection to help students develop a more meaningful conceptual understanding.

The results of the teacher needs assessment further supported the findings obtained from the students. All investigated aspects were categorized as needed to highly needed. The deep learning aspect obtained the highest percentage at 100.00%, while the use of educational technology and the need for a Google Sites-based LMS each obtained 91.67%. Meanwhile, the physics learning and conceptual understanding aspect obtained 83.33%. These results indicate that teachers perceive deep learning and the integration of technology as important components in supporting more effective physics learning. Detailed results of the teacher needs assessment are presented in Table 3.

Table 3. Results of the Teacher Needs Assessment by Aspect

No.	Aspect	Obtained Score	Maximum Score	Percentage (%)	Interpretation
1	Current Conditions of Physics Learning	30	36	83.33	Highly Needed
2	Conceptual Understanding of Physics	30	36	83.33	Highly Needed
3	Use of Educational Technology	33	36	91.67	Highly Needed
4	Deep Learning	36	36	100.00	Highly Needed
5	Need for a <i>Google Sites</i> -Based LMS	33	36	91.67	Highly Needed

These findings indicate that teachers require a digital learning environment that is easy to manage and access while maintaining a clear pedagogical structure to support physics learning. This finding is consistent with the studies of Ningsih and Bukit (2022) and Herliana et al. (2024), which reported that *Google Sites* can be utilized as a flexible and user-friendly web-based learning platform for both teachers and students. Therefore, the results of the needs assessment served as the basis for determining the structure, features, and learning activities to be integrated into the *Google Sites*-based LMS.

3.2 Design of a *Google Sites*-Based LMS Integrated with Deep Learning

Based on the results of the needs assessment, a *Google Sites*-based LMS integrated with deep learning principles was designed as a blueprint for product development in the subsequent stage. The design stage aimed to determine the LMS structure, navigation flow, and learning activities that support Grade 10 senior high school students' conceptual understanding of work and energy.

The learning sequence within the LMS was systematically designed to enable students to progress through the learning process in a structured manner, from initial orientation to final evaluation. The design included supporting information, a pretest, deep learning-based learning activities, formative exercises, a summary, and a posttest. Each learning activity was designed according to the principles of mindful, meaningful, and joyful learning to promote students' active engagement in constructing their understanding of physics concepts. The flowchart of the LMS design is presented in Figure 2.

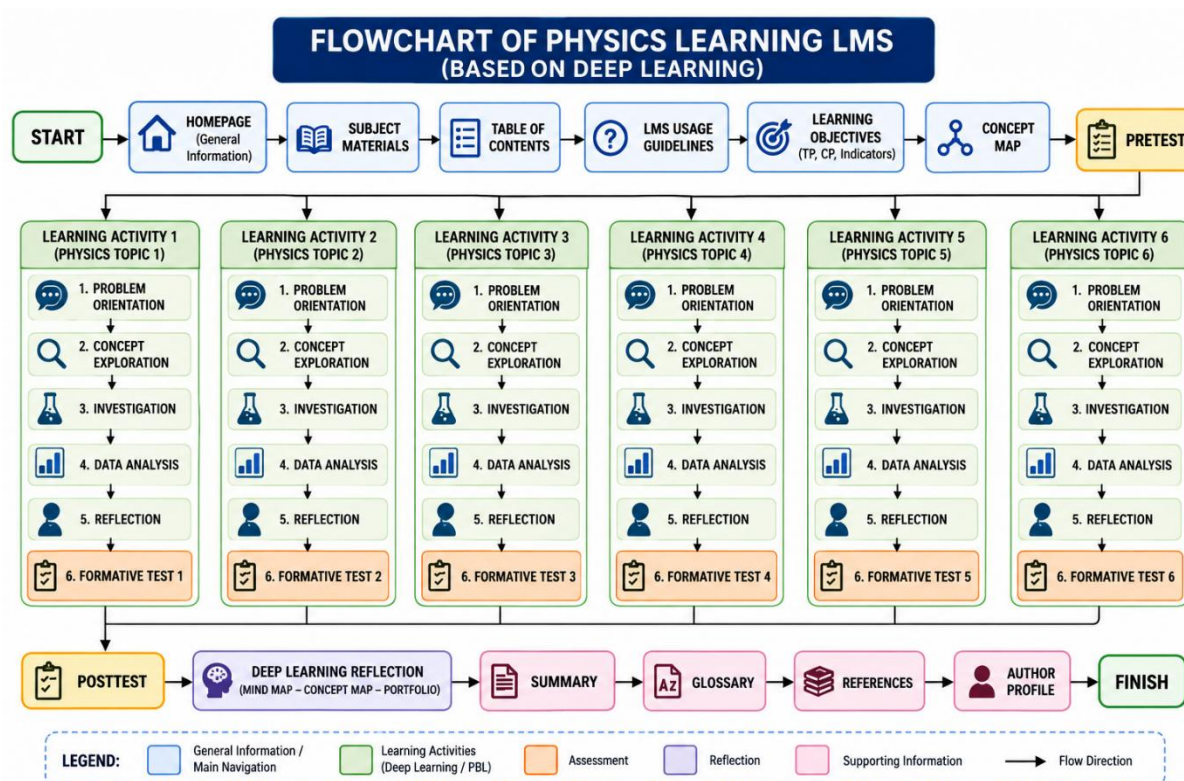


Figure 2. Navigation Flowchart of the *Google Sites*-Based LMS Integrated with Deep Learning

Based on Figure 2, the LMS was designed with a structured learning sequence consisting of a pretest, deep learning-based learning activities, formative assessments, a posttest, and reflection activities. This learning sequence was intended to support mindful, meaningful, and joyful learning in developing students' conceptual understanding of work and energy. The implementation of each LMS feature and its corresponding instructional function is presented in detail in Table 4.

Table 4. LMS Design Components and Their Instructional Functions

No.	Component	Implementation	Instructional Function
1	Homepage and User Guidelines	Learning objectives, user guidelines, learning sequence, and main navigation.	Helps students understand the learning stages in a mindful and structured manner.
2	Contextual Apperception	Everyday phenomena, images or short videos, and guiding questions.	Connects physics concepts with students' real-life experiences.
3	Structured Learning Materials	Summaries, concept maps, multiple representations, examples, and scaffolded explanations.	Supports the systematic development of conceptual understanding.
4	Interactive Simulations	Links to or embedded PhET simulations and other relevant resources.	Encourages students to explore relationships among physical variables.
5	Exercises and Formative Quizzes	Conceptual questions, scaffolded calculations, quizzes, and feedback.	Helps students independently assess their understanding.
6	Formula Bank and Infographics	Equations, definitions of variables, units, conditions of application, and application examples.	Connects mathematical formulas with their conceptual meanings.
7	Discussion and Reflection	Question-and-answer activities, reflective questions, and simple learning journals.	Promotes interaction and students' awareness of their learning process.

The design of the *Google Sites*-based LMS integrated with deep learning principles was developed based on the results of the student and teacher needs assessments. The LMS was designed with a systematic learning sequence comprising the homepage, learning materials, student worksheets (LKPD), formative quizzes, and learning reflection activities to support structured physics learning. The LMS homepage, which serves as the main interface integrating various learning features, is presented in Figure 3.

Furthermore, the LMS was developed by incorporating deep learning principles through mindful, meaningful, and joyful learning activities. The implementation of these three principles within the LMS learning components is presented in Figure 4.



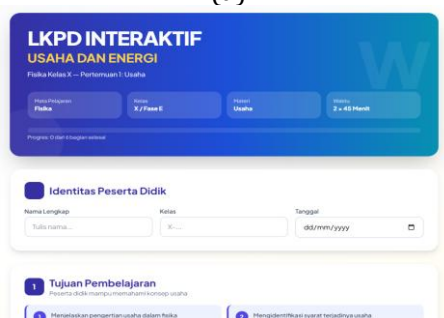
Figure 3. Homepage of the Google Sites–Based LMS Integrated with Deep Learning



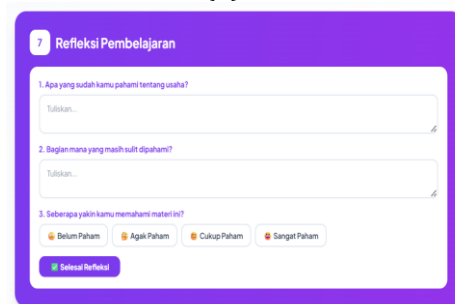
(a)



(b)



(c)



(d)

Figure 4. Examples of the Integration of Deep Learning Principles into the LMS through (a) User Guidelines, (b) Learning Videos, (c) Interactive Student Worksheets, and (d) Student Self-Reflection

3.3 Development and Expert Validation

During the development stage, the LMS design prepared in the previous stage was implemented as a prototype of a *Google Sites*-based LMS integrated with deep learning principles. The prototype

incorporated various learning components, including work and energy materials, instructional videos, interactive simulations, exercises, formative quizzes, and learning reflection activities. Prior to the practicality test, the prototype was evaluated by expert validators to ensure the appropriateness of its content, interface design, navigation, and language use.

The validation was conducted by two experts who were lecturers in Physics Education at Universitas Riau and had more than five years of experience in instructional media development and physics education. The involvement of two to three experts during the initial validation stage is commonly employed in development research to obtain feedback on content, media, and language aspects before the product is tested with its target users (Akbar, 2013; Sugiyono, 2019; Tegeh et al., 2014). The assessment covered three main aspects: content and pedagogy, media, and language.

Following the expert validation process, data were obtained regarding the validity of the *Google Sites*-based LMS integrated with deep learning principles in terms of content and pedagogy, media, and language. A summary of the validation results is presented in Table 5.

Table 5. Validation Results of the *Google Sites*-Based LMS Integrated with Deep Learning

No.	Aspect	Assessment Indicator	Percentage (%)	Category
1	Content & Pedagogy	Alignment of content with learning outcomes	88.89	HV
2	Content & Pedagogy	Accuracy of the physics concepts presented	86.11	HV
3	Content & Pedagogy	Alignment of content with learning objectives	88.89	HV
4	Content & Pedagogy	Clarity of content presentation	83.33	HV
5	Content & Pedagogy	Ability of the content to support conceptual understanding	86.11	HV
6	Content & Pedagogy	Integration of deep learning principles	83.33	HV
7	Content & Pedagogy	Appropriateness of learning activities	88.89	HV
8	Content & Pedagogy	Quality of learning assessment	83.33	HV
9	Content & Pedagogy	Alignment of student worksheets with the learning content	86.11	HV
Average – Content & Pedagogy				86.11
1	Media	Ease of navigation	88.89	HV
2	Media	Quality of visual appearance	83.33	HV
3	Media	Design consistency	86.11	HV
4	Media	Text readability	88.89	HV
5	Media	LMS interactivity	83.33	HV
6	Media	Multimedia integration	83.33	HV
7	Media	LMS accessibility	83.33	HV
8	Media	Clarity of user guidelines	86.11	HV
9	Media	Effectiveness of learning features	86.11	HV
Average – Media			85.56	HV
1	Language	Appropriateness of Indonesian language use	85.00	HV
2	Language	Clarity of sentences	82.50	HV
3	Language	Text readability	82.50	HV
4	Language	Accuracy of terminology	85.00	HV
Average – Language				83.75
Overall Average				85.14

Note: HV = Highly Valid

Based on Table 5, the *Google Sites*-based LMS integrated with deep learning was categorized as highly valid across all assessment aspects. The content and pedagogy aspect achieved a validity percentage of 86.11%, the media aspect 85.56%, and the language aspect 83.75%. The high validity of the content and pedagogy aspect indicates that the learning materials were aligned with the expected learning outcomes, learning objectives, and indicators of conceptual understanding. Furthermore, the presentation of learning materials through contextual phenomena, instructional videos, interactive simulations, and reflection

activities enables students to establish connections between physics concepts and authentic learning experiences. These characteristics are consistent with the principles of deep learning, which emphasize students' active engagement in constructing knowledge through exploration, reflection, and problem-solving (Fullan et al., 2018; Feriyanto & Anjariyah, 2024).

The high validity of the media aspect indicates that the developed LMS provides an interface, navigation system, and content structure that effectively support the learning process. The use of *Google Sites* enables the integration of various learning resources within a single platform, allowing students to access learning materials, student worksheets, videos, simulations, and assessments in an organized manner. This finding is consistent with the studies conducted by Sevtia et al. (2022) and Purba et al. (2024), which reported that *Google Sites*-based learning media can support the systematic presentation of physics content and contribute to students' mastery of concepts.

Meanwhile, the language aspect, which was also categorized as highly valid, indicates that the language used throughout the LMS met the criteria of readability, clarity, and appropriateness for senior high school students. The validation results were used not only to determine the feasibility of the product but also as a basis for improving the LMS prior to student testing. The validators provided feedback on content and pedagogy, media, and language aspects. The revisions included improving the wording of the learning materials to make them more communicative, ensuring the consistent use of physics terminology, refining the layout of several LMS menus, and adding user guidelines to facilitate students' access to the learning features. Overall, the *Google Sites*-based LMS integrated with deep learning was categorized as highly valid, indicating that it was suitable for proceeding to the practicality testing stage. However, the effectiveness of the LMS in improving students' conceptual understanding of physics needs to be further investigated in future studies.

3.4 Student Practicality Test

After being revised based on the validators' feedback and declared suitable for use, the *Google Sites*-based LMS integrated with deep learning was subjected to a limited-scale practicality test involving 20 senior high school students. The practicality test was conducted using a student response questionnaire covering ease of use, visual appearance, navigation, clarity of learning materials, and the usefulness of the LMS in supporting physics learning. This test aimed to obtain information regarding the ease and practicality of using the LMS by students as the target users in an authentic learning context. The results of the student practicality test are presented in Figure 5.

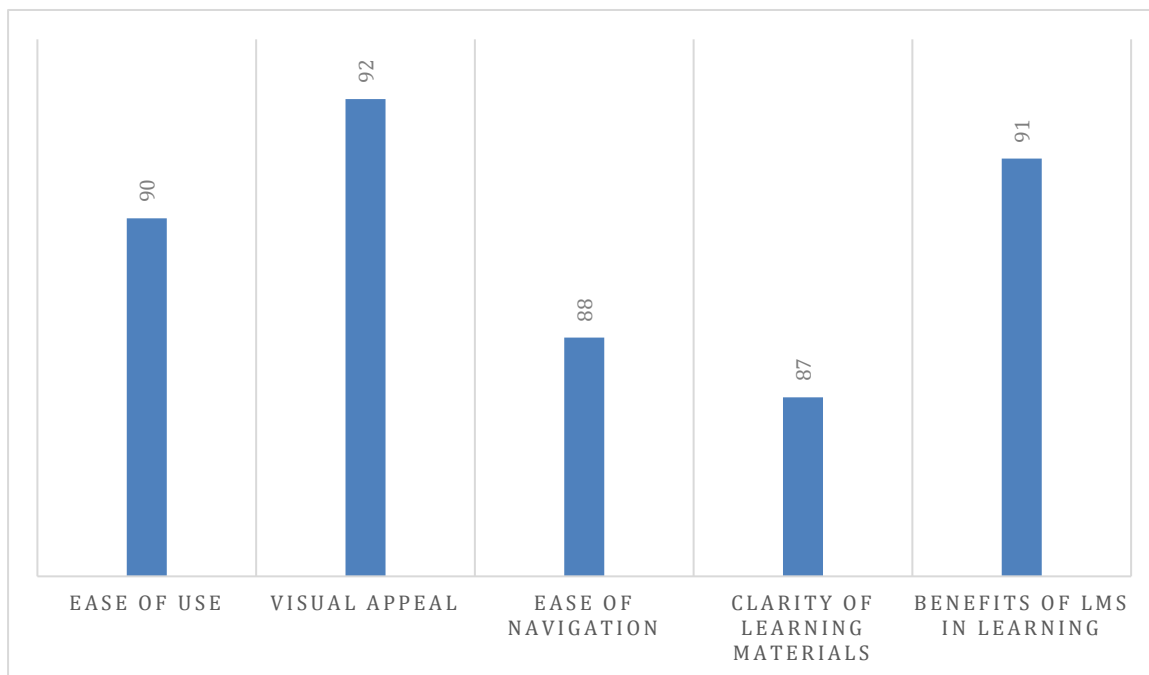


Figure 5. Results of the Student Practicality Test of the *Google Sites*–Based LMS Integrated with Deep Learning

Based on Figure 5, all aspects of practicality were categorized as highly practical. Visual attractiveness achieved the highest percentage at 92.00%, whereas clarity of learning materials obtained the lowest percentage at 87.00%. Nevertheless, the results across all aspects indicate that students were able to use the LMS effectively without experiencing significant difficulties.

These results indicate that the developed *Google Sites*–based LMS provides an attractive interface, is easy to operate, and enables students to independently follow the learning sequence. The high level of practicality was supported by a simple navigation structure and the integration of various learning resources within a single platform, enabling students to access learning materials, instructional videos, interactive simulations, student worksheets, formative quizzes, and learning reflection activities in an organized manner. These features not only facilitate students' use of the LMS but also contribute to creating mindful, meaningful, and joyful learning experiences.

The high level of practicality indicates that the product is not only theoretically feasible based on expert validation but can also be effectively used by the target users in authentic learning situations. This finding is consistent with Walidain et al. (2024), who reported that students' positive responses to technology-based physics learning methods and media are associated with ease of use and increased student engagement during the learning process. Furthermore, the findings support Herliana et al. (2024), who reported that *Google Sites* offers a high level of usability and can facilitate more flexible and interactive learning activities.

3.5 Overall Product Feasibility

Overall, the results of expert validation and the practicality test indicate that the *Google Sites*–based LMS integrated with deep learning has met the feasibility criteria for use in senior high school physics learning. The validation results demonstrated that the LMS was categorized as highly valid in terms of content and pedagogy, media, and language. In addition, the practicality test results indicated that the LMS

was categorized as highly practical based on students' responses. These findings demonstrate that the developed LMS provides high-quality content, interface design, navigation, and language use while remaining easy to use during the learning process. The findings of this study indicate that integrating deep learning principles into a *Google Sites*-based LMS can provide a feasible digital learning environment to support physics learning on the topic of work and energy. Features such as contextual phenomena, instructional videos, interactive simulations, student worksheets, formative quizzes, and learning reflection activities provide students with opportunities to engage in more mindful, meaningful, and joyful learning experiences.

Nevertheless, this study was limited to evaluating the validity and practicality of the developed product. The practicality test was conducted on a limited scale involving 20 senior high school students; therefore, the findings cannot yet be generalized to a broader population. Furthermore, this study did not examine the effectiveness of the LMS in improving students' conceptual understanding of physics. Future studies should therefore involve larger and more diverse samples and employ experimental research designs to evaluate the effectiveness of the LMS in improving students' conceptual understanding of physics.

4. Conclusions and Recommendations

Based on the results of expert validation and the student practicality test, this study successfully developed a *Google Sites*-based Learning Management System (LMS) integrated with deep learning to support senior high school students' conceptual understanding of physics, particularly on the topic of work and energy. The findings demonstrated that the developed LMS met the criteria for being highly valid based on assessments of content and pedagogy, media, and language, and was categorized as highly practical based on students' responses. Therefore, the *Google Sites*-based LMS integrated with deep learning is considered feasible for use as a physics learning medium to support mindful, meaningful, and joyful learning experiences. Nevertheless, this study was limited to evaluating the validity and practicality of the product and involved a relatively limited number of respondents during the practicality testing stage. Future research is therefore recommended to involve larger and more diverse samples and employ experimental research designs to investigate the effectiveness of the LMS in improving students' conceptual understanding across various physics topics.

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