

Development of a Google Sites-Based Learning Management System for Mathematics Learning in Senior High School: A Digital Innovation Aligned with SDG 4

Luthfi Afdil Azis^{1*}, Abna Hidayati¹, Darmansyah¹, Ulfia Rahmi¹

¹ Educational Technology, Universitas Negeri Padang, Padang, Indonesia.

Received: June 15, 2026

Revised: August 13, 2026

Accepted: August 28, 2026

Published: August 31, 2026

Corresponding Author:

Luthfi Afdil Azis

luthfiafdilazis@gmail.com

DOI: [10.29303/jppipa.v12i8.15711](https://doi.org/10.29303/jppipa.v12i8.15711)

 Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)



Abstract: The integration of digital technology into mathematics education has become increasingly important to support student-centered learning and improve instructional quality in senior high schools. This study aimed to develop and evaluate a Google Sites-based Learning Management System (LMS) for mathematics learning. The study employed a Research and Development (R&D) approach using the Plomp development model, consisting of the preliminary research, prototyping, and assessment phases. During the assessment phase, the effectiveness of the developed LMS was evaluated through a quasi-experimental design involving 71 tenth-grade students, comprising 36 students in the experimental class and 35 students in the control class, as well as mathematics teachers and expert validators. Data were collected through observations, interviews, validation sheets, practicality questionnaires, and mathematics achievement tests. The developed LMS demonstrated a high level of validity, with an average expert validation score of 4.78. Practicality evaluation indicated that the LMS was categorized as very practical, obtaining scores of 95.00% from teachers and 90.40% from students. The effectiveness test revealed that the experimental class achieved a significantly higher mean score (84.72) than the control class (76.18), with an Independent Sample *t*-test significance value of 0.002 ($p < 0.05$). These findings indicate that the Google Sites-based LMS is a valid, practical, and effective digital learning medium for mathematics instruction. The study contributes to the implementation of technology-enhanced learning practices that are aligned with the principles of Sustainable Development Goal 4 (Quality Education).

Keywords: Google sites; Learning management system; Mathematics learning; Quality education; SDG 4

Introduction

The rapid advancement of digital technology has transformed educational practices worldwide, encouraging schools to adopt technology-enhanced learning environments that promote flexibility, accessibility, and student-centered instruction. This transformation is further reinforced by the implementation of the Merdeka Curriculum in Indonesia, which emphasizes the development of critical thinking, problem-solving, collaboration, creativity, and

digital literacy as essential competencies for the twenty-first century (Hadi et al., 2023; Indarta et al., 2022). In this context, digital learning platforms are increasingly recognized as important tools for improving learning quality and expanding students' opportunities to access learning resources. These educational developments are consistent with the aspirations of Sustainable Development Goal 4 (SDG 4), which promotes inclusive and quality education through equitable learning opportunities rather than serving as a direct outcome measured in this study.

How to Cite:

Azis, L. A., Hidayati, A., Darmansyah, D., & Rahmi, U. (2026). Development of a Google Sites-Based Learning Management System for Mathematics Learning in Senior High School: A Digital Innovation Aligned with SDG 4. *Jurnal Penelitian Pendidikan IPA*, 12(7), xxxx-xxxx. <https://doi.org/10.29303/jppipa.v12i7.15711>

Mathematics is one of the fundamental subjects for developing logical reasoning, analytical thinking, and problem-solving skills required in higher education and future workplaces (Firda et al., 2023; Habibi et al., 2022). Despite its importance, many students continue to experience difficulties in understanding mathematical concepts because classroom instruction often relies on teacher-centered approaches and limited digital learning resources. Previous studies have also reported that integrating information and communication technology into mathematics instruction remains a challenge for many teachers, despite its potential to increase student engagement and improve conceptual understanding (Kusmaryono & Basir, 2024; Shé et al., 2023).

Learning Management Systems (LMSs) have become one of the most widely adopted digital technologies for supporting teaching and learning. An LMS enables teachers to organize instructional materials, facilitate communication, provide formative assessments, and monitor students' learning progress within an integrated digital environment (Aldiab et al., 2019; Medina-Flores & Morales-Gamboa, 2015). Previous research has demonstrated that LMS implementation can improve students' learning motivation, self-regulated learning, engagement, and academic achievement by providing continuous access to learning resources (Veluvali & Suriseti, 2022). Consequently, LMS-based learning has become an important strategy for creating more flexible and interactive mathematics learning environments.

Among various LMS alternatives, Google Sites offers several advantages because it is freely available, easy to develop without programming skills, and seamlessly integrates with other Google services such as Google Drive, Google Forms, YouTube, Google Classroom, and Google Docs (Bugis et al., 2023; Dwi Wicaksono & Paksi, 2023). These features enable teachers to present learning materials, instructional videos, digital worksheets, quizzes, and assessments within a single web-based platform that is accessible through computers and mobile devices. Previous studies have shown that Google Sites can improve students' learning experiences and facilitate teachers in organizing digital learning resources more effectively (Hakim & Pertiwi, 2023; Waraga et al., 2023).

Although numerous studies have reported the educational benefits of Google Sites, most have primarily examined its use as a web-based learning medium or instructional website in different subject areas. Limited attention has been given to the systematic development of a Google Sites-based Learning Management System specifically designed for senior high school mathematics learning, integrating curriculum-based instructional materials, digital

worksheets, learning videos, formative assessments, and evaluation features within a single learning environment. Furthermore, previous studies have generally focused on usability or learning outcomes, while comprehensive evaluation involving validity, practicality, and effectiveness through an educational product development framework remains relatively limited. This gap indicates the need for research that develops and rigorously evaluates a Google Sites-based LMS tailored to the characteristics of mathematics learning.

Preliminary observations conducted at SMAN 1 VII Koto Sungai Sarik revealed that digital learning had begun to be implemented; however, existing online learning resources were fragmented across multiple platforms and had not yet functioned as an integrated Learning Management System. Teachers experienced difficulties in organizing learning materials, assignments, and evaluations within a unified digital environment, while students reported challenges in accessing structured learning resources independently. These findings indicate the necessity of developing an integrated LMS capable of supporting more effective, organized, and student-centered mathematics learning.

Therefore, this study developed a Google Sites-based Learning Management System using the Plomp development model and evaluated its validity, practicality, and effectiveness in senior high school mathematics learning. The novelty of this study lies in the development of an integrated Google Sites-based LMS specifically designed according to the characteristics of mathematics instruction, combining instructional materials, digital worksheets, learning videos, interactive assessments, and learning evaluation within a single platform. Rather than claiming to measure the achievement of SDG 4 directly, this study contributes to the implementation of technology-enhanced instructional practices that are aligned with the principles of Quality Education, particularly by promoting accessible, flexible, and student-centered learning.

Method

Research Design

This study employed a Research and Development (R&D) approach to develop and evaluate a Google Sites-based Learning Management System (LMS) for senior high school mathematics learning. The development process adopted the Plomp development model, which consists of three sequential phases: preliminary research, prototyping phase, and assessment phase (Plomp et al., 1996). The Plomp model was selected because it provides a systematic framework for developing educational products through iterative design,

evaluation, and revision to ensure that the final product meets the criteria of validity, practicality, and effectiveness.

During the assessment phase, the effectiveness of the developed LMS was evaluated using a quasi-experimental design with a posttest-only control group. Two Grade X classes at SMAN 1 VII Koto Sungai Sarik participated in this stage. The experimental class learned mathematics using the Google Sites-based LMS, whereas the control class received conventional instruction. Students' mathematics learning outcomes were compared using an Independent Sample t-test to determine whether the developed LMS significantly improved learning achievement.

Development Procedure

The development procedure followed the three phases of the Plomp model.

Preliminary Research

The preliminary research phase aimed to identify instructional problems and determine the need for developing a Google Sites-based LMS. Activities included curriculum analysis, learner analysis, instructional needs analysis, and technology analysis.

Curriculum analysis examined the mathematics learning outcomes specified in the Merdeka Curriculum. Learner analysis identified students' characteristics, digital literacy, prior knowledge, and learning preferences. Instructional needs analysis was conducted through classroom observations and interviews with mathematics teachers to identify limitations in existing learning media. Technology analysis evaluated the feasibility of implementing Google Sites by considering internet availability, students' access to digital devices, and the integration of Google services that support mathematics learning (Mousavi et al., 2021; Noah & Gbemisola, 2020).

Prototyping Phase

This stage aims to produce a prototype of a Google Sites-based LMS that suits the needs of math learning. At this stage, the design of the LMS structure based on Google Sites, the preparation of mathematics learning materials, and the integration of various supporting media such as learning videos, LKPDs, interactive quizzes, and learning evaluations were carried out. Prototype development at this phase is an important part of development research because it allows researchers to produce initial products that can be tested and refined gradually before being implemented in target users (Plomp et al., 1996). The prototype that has been developed is then validated by subject matter experts and media experts to assess the feasibility of the product. The expert validation process aims to ensure

that the product developed meets the content, construction, and display aspects so that it is suitable for use in learning (Tesmer et al., 1993). Furthermore, the product is revised based on the input and suggestions provided by the validators so that an LMS that is more in line with the learning needs and characteristics of students is obtained (Nieveen, 1999).

Assessment Phase

This stage aims to evaluate the quality of the products that have been developed. At this stage, a practical test was carried out by teachers and students to determine the ease of use and implementation of LMS in learning. In addition, an effectiveness test was conducted to determine the effect of LMS use on students' mathematics learning outcomes. According to Nieveen (1999), a product developed needs to meet quality criteria in the form of validity, practicality, and effectiveness in order to be feasible to be applied in the context of learning. Therefore, the results of the practicality and effectiveness tests are used as a basis for conducting final evaluation and product improvements so that a Google Sites-based LMS is obtained that is suitable for use in the learning process (Nieveen, 1999; Plomp et al., 1996).

Data Collection Techniques

The data collection techniques used in this study include observation, interviews, questionnaires, and learning outcome tests. Observations were made during the learning process to obtain information about student activities and the use of Google Sites-based LMS in mathematics learning. According to Klatzky & Creswell (2014), Observation is a data collection technique that allows researchers to obtain direct information about the behavior and activities of research subjects in a natural context. Interviews were conducted with mathematics teachers, principals, vice principals for curriculum, and students to obtain information about learning needs, responses to the LMS developed, and input that can be used for product improvement. Interviews are used to dig deep into information related to respondents' experiences, perceptions, and needs for a phenomenon being researched (Sugiyono, 2017). In addition, questionnaires are used to obtain data on product validity and practicality. Validity questionnaires are given to material experts and media experts, while practicality questionnaires are given to teachers and students. Questionnaires are an efficient data collection technique to obtain information from a number of respondents through a series of questions or written statements (Arikunto, 2013). Furthermore, learning outcome tests were used to measure the effectiveness of using Google Sites-based LMS on the achievement of students' mathematics learning outcomes. The learning

outcome test serves to measure the level of students' mastery of the competencies that have been learned after participating in the learning process (Kubinger et al., 2010).

Research Instruments

The research instruments used in this study include material expert validation sheets and media expert validation sheets used to assess the feasibility of the developed products. Validation by experts is an important step in development research to ensure that the resulting product meets the content, construct, and display aspects that match the learning objectives (Plomp et al., 1996). In addition, teacher practicality questionnaires and student practicality questionnaires were used to obtain data on the ease of use and usefulness of Google Sites-based LMS in learning. The use of practicality questionnaires aims to find out the level of convenience, efficiency, and acceptance of the product by users (Akker et al., 2006). To measure the effectiveness of the product, a learning outcome test was used given to students. Learning outcome tests are used to determine the extent to which the developed product is able to increase the achievement of students' competencies (Arikunto, 2013). This study also uses observation sheets of learning activities to observe student involvement during the learning process as well as interview guidelines to obtain more in-depth information from respondents regarding the needs, responses, and inputs to the developed product (Klatzky & Creswell, 2014).

Data Analysis Techniques

Validity Analysis

The validity analysis aims to determine the feasibility level of a Google Sites-based LMS based on validator assessments. Validity data is analyzed using an average score with the formula:

$$\bar{x} = \frac{\sum x}{N} \quad (1)$$

Practicality Analysis

Practicality data was obtained from questionnaires filled out by teachers and students. The value of practicality is calculated using the formula:

$$P = \left(\frac{f}{N} \right) \times 100\% \quad (2)$$

Effectiveness Analysis

The effectiveness of a Google Sites-based LMS is analyzed based on student learning outcomes, learning activities, and learners' responses to LMS use.

Hypothesis Test

To determine the difference in learning outcomes between the experimental class and the control class, an

Independent Sample t-Test was used at a significance level of 0.05.

The research hypothesis is formulated as follows:

H_0 : There was no difference in mathematics learning outcomes between students who used Google Sites-based LMS and students who used conventional learning.

H_1 : There is a difference in mathematics learning outcomes between students who use Google Sites-based LMS and students who use conventional learning.

The decision-making criteria are:

If the significance value (Sig.) > 0.05 then H_0 is accepted.

If the significance value (Sig.) ≤ 0.05 then H_0 is rejected.

The Relevance of Research to SDGs 4

The development of Google Sites-based LMS in this study supports the achievement of Sustainable Development Goal 4 (Quality Education) through the provision of a digital learning environment that is easily accessible, interactive, flexible, and oriented towards improving the quality of mathematics learning. The LMS developed is expected to be able to expand access to quality learning resources and encourage the realization of inclusive and student-centered learning.

Result and Discussion

Preliminary Research Results

The preliminary research phase was conducted to identify the instructional needs and determine the feasibility of developing a Google Sites-based Learning Management System (LMS) for mathematics learning at SMAN 1 VII Koto Sungai Sarik. This phase included curriculum analysis, learner analysis, instructional needs analysis, and technology analysis. The findings from these analyses served as the foundation for designing the LMS according to the characteristics of mathematics learning and the requirements of the Merdeka Curriculum.

Curriculum Analysis

The curriculum analysis indicated that mathematics learning in Phase E of the Merdeka Curriculum emphasizes students' ability to think critically, solve problems, communicate mathematical ideas, and apply digital literacy skills. Consequently, learning media should not only facilitate content delivery but also provide opportunities for students to engage in independent and interactive learning. These findings highlight the importance of integrating digital learning environments capable of supporting competency-based mathematics instruction.

Learner Analysis

Observations and interviews revealed that most Grade X students possessed smartphones and had adequate internet access to participate in digital learning activities. Students expressed positive attitudes toward technology-supported instruction because it allowed them to access learning materials more flexibly inside and outside the classroom. However, differences in learning pace and conceptual understanding indicated the need for learning media that could accommodate individualized learning.

Technology Analysis

The technology analysis demonstrated that Google Sites provides an appropriate platform for developing an integrated LMS because it can be connected with Google Forms, Google Drive, YouTube, Google Docs, and other digital resources without requiring advanced programming skills. In addition, the platform is freely accessible and compatible with computers as well as mobile devices, making it suitable for supporting flexible mathematics learning in secondary schools.

Results of Google Sites-Based LMS Development

The development of the Google Sites-based Learning Management System (LMS) was carried out during the prototyping phase of the Plomp development model. The LMS was designed based on the findings obtained during the preliminary research, including curriculum analysis, learner characteristics, instructional needs, and technology analysis. These findings indicated the need for an integrated digital learning environment that enables students to access mathematics learning materials, assignments, assessments, and learning resources through a single online platform.

The development process began with the preparation of the instructional design, which included determining the learning outcomes, organizing mathematics content according to the Merdeka Curriculum, selecting appropriate learning media, and designing user navigation. The LMS interface was then developed using Google Sites because of its ease of use, compatibility with multiple devices, and seamless integration with Google Workspace applications, including Google Forms, Google Drive, Google Docs, and YouTube. This integration enables teachers to organize instructional materials systematically while providing students with continuous access to learning resources anytime and anywhere.

The completed LMS consists of several interconnected learning components that support the entire learning process. The homepage functions as the main navigation interface, providing users with access to all instructional features. Learning outcomes and

lesson objectives are presented to help students understand the competencies expected in each lesson. Mathematics learning materials are organized systematically and accompanied by instructional videos to facilitate conceptual understanding. Digital worksheets (LKPD) and interactive quizzes encourage students to actively participate in learning activities and receive immediate feedback. Furthermore, an online evaluation module enables teachers to assess students' learning outcomes efficiently, while the references section provides additional learning resources to support independent learning.

The integration of these instructional components creates a comprehensive learning environment that supports both classroom instruction and self-directed learning. Unlike conventional learning media that present instructional resources separately, the developed LMS organizes all learning activities within a single platform, allowing teachers to manage learning more efficiently while enabling students to access instructional resources in a structured and flexible manner.

Product Display



Figure 1. Google sites-based LMS home page

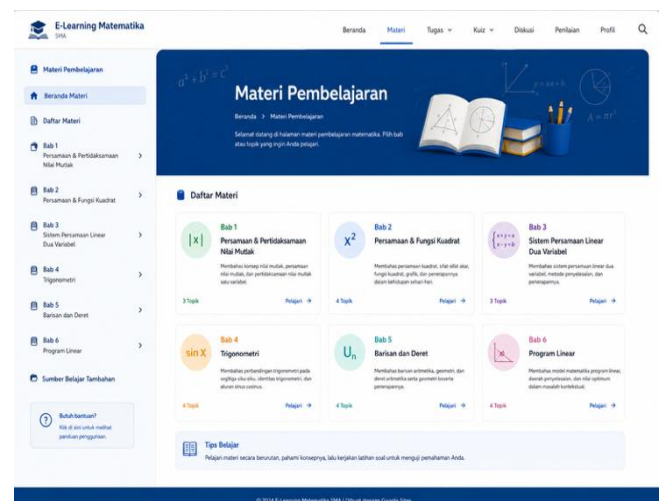


Figure 2. Learning materials page

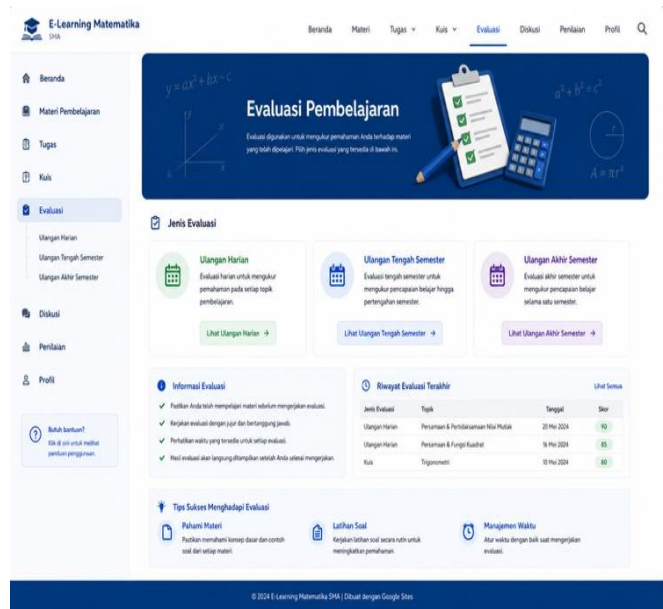


Figure 3. Learning evaluation page

Validation Results

Validation was conducted to evaluate the feasibility of the developed Google Sites-based Learning Management System (LMS) before classroom implementation. The validation process involved two subject-matter experts and two instructional media experts, who assessed the product based on content accuracy, instructional design, language, interface quality, navigation, interactivity, and accessibility. The results of expert validation were used as the basis for revising and improving the prototype before proceeding to the practicality and effectiveness evaluations.

Material Expert Validation Results

The material experts evaluated the LMS in terms of material suitability, conceptual accuracy, content presentation, and language appropriateness. The validation results are presented in Table 1.

Table 1. Material expert validation results

Assessment Aspects	Average score	Category
Material Suitability	4.86	Very valid
Truth of the Concept	4.75	Very valid
Presentation of Materials	4.70	Very valid
Language	4.80	Very valid
Average	4.78	Very valid

The overall mean score of 4.78 indicates that the developed LMS achieved a very valid level of quality. Material experts agreed that the instructional content was consistent with the mathematics learning outcomes specified in the Merdeka Curriculum and accurately represented mathematical concepts. The presentation of learning materials was considered systematic and

logically organized, enabling students to follow the learning sequence more effectively. In addition, the language used throughout the LMS was regarded as clear, concise, and appropriate for senior high school students, thereby facilitating students' comprehension of mathematical concepts.

These findings demonstrate that the instructional design successfully integrates curriculum objectives, mathematical content, and digital learning resources within a coherent learning environment. Consequently, the developed LMS satisfies the content validity requirements and is appropriate for classroom implementation after minor revisions suggested by the validators.

Media Expert Validation Results

Media experts evaluated the LMS based on interface design, navigation, interactivity, and accessibility. The validation results are presented in Table 2.

Table 2. Media expert validation results

Assessment Aspects	Average Score	Category
Display	4.80	Very valid
Navigation	4.75	Very valid
Interactivity	4.70	Very valid
Ease of Access	4.85	Very valid
Average	4.78	Very valid

The media validation produced an overall mean score of 4.78, indicating that the developed LMS was categorized as very valid. According to the validators, the LMS interface was visually organized, user-friendly, and consistent across learning pages. The navigation structure enabled students to locate learning materials, assignments, and assessments efficiently without experiencing unnecessary complexity. Furthermore, the integration of multimedia resources including instructional videos, digital worksheets, and online quizzes enhanced the interactivity of the learning environment while maintaining ease of access across computers and mobile devices.

The accessibility score received the highest evaluation because Google Sites allows learners to access instructional resources using various devices without requiring software installation or advanced technical skills. These characteristics increase the practicality of the LMS for classroom implementation and support students' independent learning beyond regular classroom hours.

The high validity scores obtained from both subject-matter experts and media experts indicate that the developed Google Sites-based LMS satisfies essential quality criteria for educational products, including content accuracy, instructional design, interface quality, and usability. These findings are consistent with the

educational product quality framework proposed by (Nieveen, 1999), which emphasizes that an instructional product should demonstrate strong content validity and design validity before implementation.

The results also corroborate previous studies reporting that Google Sites provides an effective platform for organizing digital learning resources within a structured instructional environment. For example, Hakim & Pertiwi (2023) reported that Google Sites-based instructional media achieved a very valid category because of its systematic presentation of learning materials and user-friendly interface. Similarly, Waraga et al. (2023) found that Google Sites effectively supports interactive science learning by integrating multimedia resources into a single digital platform. The consistency of these findings suggests that Google Sites is a reliable platform for developing instructional media across different subject areas, including mathematics.

Unlike previous studies that primarily focused on Google Sites as a web-based instructional medium, the present study developed a fully integrated Learning Management System that combines curriculum-based learning materials, instructional videos, digital worksheets, interactive quizzes, and online evaluations within a single platform. This integrated design strengthens the instructional coherence of the LMS and represents the principal contribution of the present study.

Practicality Result

The practicality of the developed Google Sites-based Learning Management System (LMS) was evaluated by a mathematics teacher after the classroom implementation. The evaluation focused on four aspects: ease of use, learning efficiency, usefulness for instruction, and overall practicality. The results are presented in Table 3.

Table 3. Results of teacher practicality

Assessment Aspects	Average Score	Category
Ease of use	95.00	Very valid
Learning efficiency	93.33	Very valid
Benefits of learning	96.67	Very valid
Average	95.00	Very valid

The teacher practicality evaluation yielded an overall score of 95.00%, indicating that the developed Google Sites-based LMS was categorized as very practical for mathematics learning. Among the evaluated aspects, instructional usefulness received the highest score (96.67%), followed by ease of use (95.00%) and learning efficiency (93.33%). These findings suggest that the LMS successfully supports teachers in organizing instructional activities and managing digital learning resources.

According to the teacher's evaluation, the LMS simplified the preparation and delivery of mathematics instruction by integrating learning materials, instructional videos, digital worksheets, quizzes, and assessments within a single platform. This integration reduced the need to switch between multiple applications during classroom instruction and enabled more systematic management of learning activities. Furthermore, the simple navigation structure and compatibility with various digital devices allowed teachers to implement the LMS without requiring extensive technical training.

The high practicality score also reflects the flexibility of Google Sites as a web-based learning platform. Because the LMS can be accessed through computers, tablets, and smartphones without requiring additional software installation, teachers can manage instructional activities more efficiently while providing students with continuous access to learning resources beyond classroom hours. These characteristics are particularly valuable in supporting blended and technology-enhanced learning environments.

The findings of this study are consistent with previous research reporting the practicality of Google Sites in educational settings. Hakim & Pertiwi (2023) found that Google Sites-based instructional media facilitated classroom implementation because of its intuitive interface, organized content structure, and ease of navigation. Similarly, Waraga et al. (2023) reported that Google Sites effectively supported teachers in managing digital learning resources and increased instructional efficiency during classroom implementation. In addition, Nurwina et al. (2025) demonstrated that Google Sites-based teaching materials were well accepted by teachers because they enabled flexible learning management and promoted more interactive classroom activities.

Compared with previous studies, the present research extends existing knowledge by demonstrating that Google Sites can function not only as a web-based instructional medium but also as an integrated Learning Management System specifically designed for senior high school mathematics learning. The high teacher practicality score indicates that integrating instructional materials, digital worksheets, online assessments, and learning resources within a single platform substantially reduces teachers' instructional workload while improving the organization of classroom learning.

Product Effectiveness Results

The effectiveness of the developed Google Sites-based Learning Management System (LMS) was evaluated during the assessment phase by comparing the mathematics learning outcomes of students in the experimental class with those in the control class. Prior

to hypothesis testing, the data were subjected to normality and homogeneity tests to ensure that the assumptions for parametric analysis were satisfied.

Table 4. Student learning outcomes

Class	Number of students	Average
Experiment	36	84.7
Control	35	76.1

As shown in Table 4, the experimental class achieved a higher mean score (84.7) than the control class (76.1). These descriptive findings indicate that students who learned using the Google Sites-based LMS demonstrated better mathematics learning outcomes than those who received conventional instruction. However, inferential statistical analysis was conducted to determine whether this difference was statistically significant.

Normality Test

The normality of the learning outcome data was examined using the Shapiro–Wilk test. The results are presented in Table 5.

Table 5. Results of the Shapiro–Wilk normality test

Class	Sig.	Interpretation
Experiment	>0.05	Normally distributed
Control	>0.05	Normally distributed

The results indicate that the significance values for both groups were greater than 0.05, confirming that the learning outcome data were normally distributed. Therefore, the assumption of normality required for parametric statistical analysis was satisfied.

Homogeneity Test

The homogeneity of variance between the experimental and control groups was evaluated using Levene's Test. The results are presented in Table 6.

Table 6. Results of Levene's homogeneity test

Variable	Sig.	Interpretation
Learning outcomes	>0.05	Homogeneous variance

The significance value exceeded 0.05, indicating that the variances of the two groups were homogeneous. Consequently, the assumptions for conducting the Independent Sample t-test were fulfilled.

Independent Sample t-Test

Following the assumption testing, an Independent Sample t-test was conducted to compare the mathematics learning outcomes between the experimental and control groups. The results are presented in Table 7.

Table 7. Results of the independent sample t-test

Variable	t	df	Sig. 2-tailed	Decision
Learning outcomes	3.287	69	0.002	Reject H_0

The Independent Sample t-test produced a significance value of 0.002, which is lower than the significance level of 0.05. Therefore, the null hypothesis (H_0) was rejected, indicating a statistically significant difference in mathematics learning outcomes between students who learned using the Google Sites-based LMS and those who received conventional instruction.

The higher mean score obtained by the experimental class demonstrates that the developed LMS effectively supported students' understanding of mathematical concepts. The integration of learning materials, instructional videos, digital worksheets, formative quizzes, and online evaluations within a single learning platform enabled students to review learning resources repeatedly, receive immediate feedback, and engage in more independent learning activities. These features are likely to have contributed to the improved learning outcomes observed in the experimental group.

Discussion

The findings of this study demonstrate that the developed Google Sites-based Learning Management System (LMS) achieved a very valid category based on evaluations conducted by subject-matter experts and media experts. The high validation scores indicate that the LMS successfully met the essential criteria of educational product quality, including content accuracy, instructional design, language appropriateness, interface quality, navigation, interactivity, and accessibility. These results suggest that the systematic development process implemented through the Plomp model enabled continuous refinement of the product according to expert recommendations before classroom implementation. The integration of curriculum-based learning objectives, mathematics learning materials, instructional videos, digital worksheets, and online assessments within a single platform also contributed to the high level of content and design validity. These findings are consistent with previous studies reporting that Google Sites provides a reliable platform for developing digital learning media because of its flexibility, ease of use, and ability to integrate multiple instructional resources (Hakim & Pertiwi, 2023; Waraga et al., 2023). However, unlike previous studies that primarily focused on Google Sites as a web-based learning medium, this study developed an integrated Learning Management System specifically designed to support mathematics learning in senior high schools.

The practicality evaluation further revealed that the developed LMS was categorized as very practical by

both teachers and students. The high practicality scores indicate that the LMS was easy to use, facilitated classroom implementation, and supported efficient management of mathematics learning activities. Teachers reported that the LMS simplified instructional organization by integrating learning materials, assignments, instructional videos, and assessments within a single online environment, while students appreciated the flexibility of accessing learning resources anytime and anywhere through computers or smartphones. These characteristics reduced the need to switch between multiple digital platforms and enabled more organized learning experiences. Such findings support previous research indicating that Google Sites enhances teachers' instructional efficiency and promotes students' engagement because of its intuitive interface and accessibility (Hakim & Pertiwi, 2023; Nurwina et al., 2025). Therefore, the practicality results confirm that Google Sites can be effectively implemented as an integrated learning platform rather than merely serving as a repository of learning materials.

The effectiveness results demonstrated that students who learned using the Google Sites-based LMS achieved significantly higher mathematics learning outcomes than those receiving conventional instruction. The Independent Sample t-test showed a significance value of 0.002, confirming that the difference between the two groups was statistically significant. The improved learning outcomes can be explained by several instructional characteristics embedded within the LMS. First, students were able to access learning materials repeatedly according to their individual learning pace, thereby supporting self-regulated learning. Second, the integration of instructional videos, digital worksheets, interactive quizzes, and online evaluations created a multimedia learning environment that facilitated conceptual understanding and encouraged active engagement throughout the learning process. Third, immediate feedback provided through online assessments enabled students to identify misconceptions and improve their understanding before completing summative evaluations. These findings are consistent with previous studies reporting that Google Sites-based learning environments improve students' learning achievement, learning motivation, and learning independence by providing flexible access to integrated digital learning resources (Hermawati & Yulianto, 2025; Herniawati et al., 2025; Mahfuzh et al., 2024).

Overall, this study demonstrates that a Google Sites-based Learning Management System can serve as an effective digital learning innovation for mathematics education in senior high schools. The integration of instructional materials, multimedia resources, digital worksheets, formative assessments, and online evaluations within a single platform provides a more

structured, interactive, and student-centered learning environment. These findings contribute to the growing body of evidence supporting the use of freely accessible digital technologies to improve instructional quality in secondary education. Although this study was conducted within a single school context, the developed LMS illustrates how technology can enhance classroom learning practices in ways that are aligned with the principles of Sustainable Development Goal 4 (Quality Education) by promoting accessible, flexible, and inclusive learning opportunities. Future research is recommended to evaluate the implementation of this LMS across different schools, mathematical topics, and educational contexts to further examine its effectiveness and scalability.

Conclusion

This study successfully developed a Google Sites-based Learning Management System (LMS) for senior high school mathematics learning using the Plomp development model. The evaluation results demonstrated that the developed LMS met the criteria of validity, practicality, and effectiveness. Expert validation confirmed that the LMS was categorized as very valid in terms of content, instructional design, interface quality, and accessibility. The practicality evaluation showed that both teachers and students perceived the LMS as very practical, indicating that it was easy to use and effectively supported classroom instruction. Furthermore, the effectiveness evaluation revealed that the learning outcomes of students who learned using the Google Sites-based LMS were significantly higher than those of students receiving conventional instruction ($p = 0.002$). These findings indicate that the developed LMS is an effective digital learning medium for supporting mathematics instruction and promoting more flexible, interactive, and student-centered learning practices. Although this study was conducted in a single senior high school, the findings provide evidence that a Google Sites-based LMS can contribute to improving classroom-level instructional quality through the integration of digital learning resources within a unified platform. Therefore, the developed LMS represents a practical technology-enhanced learning innovation that is aligned with the principles of Sustainable Development Goal 4 (Quality Education). Future studies are recommended to evaluate the implementation of the LMS in different schools, broader mathematics topics, and diverse educational contexts. In addition, further research may integrate emerging technologies, such as artificial intelligence, learning analytics, or adaptive learning systems, to

enhance personalized learning experiences and improve students' learning outcomes.

Acknowledgments

The authors would like to express their sincere gratitude to Prof. Dr. Abna Hidayati, M.Pd., as the principal supervisor, for her valuable guidance, constructive suggestions, and continuous support throughout the research process. The authors also extend their appreciation to Prof. Dr. Darmansyah, S.T., M.Pd., and Dr. Ulfia Rahmi, M.Pd., as examiners, for their insightful comments, critical feedback, and recommendations that significantly improved the quality of this study. Special thanks are addressed to the principal, mathematics teachers, and students of SMAN 1 VII Koto Sungai Sarik for their cooperation and participation during the implementation of this research. Their contributions were invaluable to the successful completion of this study.

Author Contributions

Conceptualization, L.A.A. and A.H.; methodology, software, formal analysis, investigation, resources, data curation, writing—original draft preparation, visualization, L.A.A.; validation, A.H., D., and U.R.; writing—review and editing, supervision, A.H. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Akker, J. M. V. D., Hoogeveen, J. A., & Kempen, J. W. V. (2006). Parallel Machine Scheduling Through Column Generation: Minimax Objective Functions. In Y. Azar & T. Erlebach (Eds.), *Algorithms – ESA 2006* (Vol. 4168, pp. 648–659). Springer Berlin Heidelberg. https://doi.org/10.1007/11841036_58
- Aldiab, A., Chowdhury, H., Kootsookos, A., Alam, F., & Allhibi, H. (2019). Utilization of Learning Management Systems (LMSs) in Higher Education System: A Case Review for Saudi Arabia. *Energy Procedia*, 160, 731–737. <https://doi.org/10.1016/j.egypro.2019.02.186>
- Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktek*. Jakarta: Rineka Cipta.
- Bugis, F., Wirasti, M. K., & Nurani, Y. (2023). Utilization of a Learning Management System to Develop Critical Thinking Skills. *Scaffolding: Jurnal Pendidikan Islam dan Multikulturalisme*, 5(2), 243–255. <https://doi.org/10.37680/scaffolding.v5i2.2191>
- Firda, N., Suryadi, D., & Dahlan, J. A. (2023). Mathematical Problem-Solving Ability of Junior High School Students Based on Polya. *Edumatica: Jurnal Pendidikan Matematika*, 13(03), 273–284. <https://doi.org/10.22437/edumatica.v13i03.29287>
- Habibi, M., Wahyuni, N., Rusliah, N., Ilham, M., & Fitri, I. (2022). Effect of Mathematics Anxiety and Intelligence on Students' Logical Thinking Ability. *Edumatica: Jurnal Riset Pendidikan Matematika*, 4(2), 77–89. <https://doi.org/10.32939/ejrpm.v4i2.1102>
- Hadi, A., Marniati, M., Ngindana, R., Kurdi, M. S., Kurdi, M. S., & Fauziah, F. (2023). New Paradigm of Merdeka Belajar Curriculum in Schools. *AL-ISHLAH: Jurnal Pendidikan*, 15(2), 1497–1510. <https://doi.org/10.35445/alishlah.v15i2.3126>
- Hakim, D. R., & Pertiwi, K. R. (2023). Development of Innovative Student Worksheet Using Google Sites for Reproductive System Material. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7484–7490. <https://doi.org/10.29303/jppipa.v9i9.4429>
- Hermawati, V., & Yulianto, S. (2025). Development of Google Sites Website Based Learning Media to Improve IPAS Learning Outcomes on the Material of Sound and Its Propertie. *Jurnal Penelitian Pendidikan IPA*, 11(2), 654–662. <https://doi.org/10.29303/jppipa.v11i2.10277>
- Herniawati, A., Holifah, L., & Syakur, A. (2025). Effectiveness of Learning Management System (LMS) Use in Higher Education. *International Journal Corner of Educational Research*, 4(1), 20–29. <https://doi.org/10.54012/ijcer.v4i1.625>
- Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0. *EDUKATIF: Jurnal Ilmu Pendidikan*, 4(2), 3011–3024. <https://doi.org/10.31004/edukatif.v4i2.2589>
- Klatzky, R. L., & Creswell, J. D. (2014). An Intersensory Interaction Account of Priming Effects—And Their Absence. *Perspectives on Psychological Science*, 9(1), 49–58. <https://doi.org/10.1177/1745691613513468>
- Kubinger, K. D., Holocher-Ertl, S., Reif, M., Hohensinn, C., & Frebort, M. (2010). On Minimizing Guessing Effects on Multiple-Choice Items: Superiority of a Two Solutions and Three Distractors Item Format to a One Solution and Five Distractors Item Format. *International Journal of Selection and Assessment*, 18(1), 111–115. <https://doi.org/10.1111/j.1468-2389.2010.00493.x>
- Kusmaryono, I., & Basir, M. A. (2024). Learning Media Projects with YouTube Videos: A Dynamic Tool for Improving Mathematics Achievement. *International Journal of Evaluation and Research in Education (IJERE)*, 13(2), 934. <https://doi.org/10.11591/ijere.v13i2.26720>
- Mahfuzh, M. S., Remiswal, R., & Khadijah, K. (2024). Evaluasi Pembelajaran Interaktif dalam Meningkatkan Keterampilan Berpikir Kritis Siswa di SMPN 2 Sintoga. *An-Nahdlah: Jurnal Pendidikan*

- Islam*, 4(1), 122-133. <https://doi.org/10.51806/an-nahdlah.v4i1.152>
- Medina-Flores, R., & Morales-Gamboa, R. (2015). Usability Evaluation by Experts of a Learning Management System. *IEEE Revista Iberoamericana de Tecnologías Del Aprendizaje*, 10(4), 197-203. <https://doi.org/10.1109/RITA.2015.2486298>
- Mousavi, S. M., Abdullah, S., Niaki, S. T. A., & Banihashemi, S. (2021). An Intelligent Hybrid Classification Algorithm Integrating Fuzzy Rule-Based Extraction and Harmony Search Optimization: Medical Diagnosis Applications. *Knowledge-Based Systems*, 220, 106943. <https://doi.org/10.1016/j.knosys.2021.106943>
- Nieveen, N. (1999). Prototyping to Reach Product Quality. In J. Van Den Akker, R. M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design Approaches and Tools in Education and Training* (pp. 125-135). Springer Netherlands. https://doi.org/10.1007/978-94-011-4255-7_10
- Noah, O., O., & Gbemisola, K. O. (2020). Impact of Google Classroom as an Online Learning Delivery during COVID-19 Pandemic: The Case of a Secondary School in Nigeria. *Journal of Education, Society and Behavioural Science*, 33(1), 53-61. <https://doi.org/10.9734/jesbs/2020/v33i930259>
- Nurwina, A., Yani, A., & Arsyad, M. (2025). Development of Physics Teaching Materials Based on Google Sites to Improve Students' Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, 11(7), 359-370. <https://doi.org/10.29303/jppipa.v11i7.11871>
- Plomp, T., Nieveen, N., & Pelgrum, H. (1996). Curricular Aspects of Computers in Education. In T. Plomp, R. E. Anderson, & G. Kontogiannopoulou-Polydorides (Eds.), *Cross National Policies and Practices on Computers in Education* (pp. 9-26). Springer Netherlands. https://doi.org/10.1007/978-0-585-32767-9_2
- Shé, C. N., Fhloinn, E. N., & Bhaird, C. M. A. (2023). Student Engagement with Technology-Enhanced Resources in Mathematics in Higher Education: A Review. *Mathematics*, 11(3), 787. <https://doi.org/10.3390/math11030787>
- Sugiyono, S. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, CV.
- Tesmer, V. M., Rajadhyaksha, A., Babin, J., & Bina, M. (1993). NF-IL6-Mediated Transcriptional Activation of the Long Terminal Repeat of the Human Immunodeficiency Virus Type 1. *Proceedings of the National Academy of Sciences*, 90(15), 7298-7302. <https://doi.org/10.1073/pnas.90.15.7298>
- Veluvali, P., & Suriseti, J. (2022). Learning Management System for Greater Learner Engagement in Higher Education—A Review. *Higher Education for the Future*, 9(1), 107-121. <https://doi.org/10.1177/23476311211049855>
- Waraga, S. S., Abdjul, T., & Odja, A. H. (2023). Development of Google Sites-Assisted Learning Devices on Vibrations and Waves Material. *Jurnal Penelitian Pendidikan IPA*, 9(8), 6101-6110. <https://doi.org/10.29303/jppipa.v9i8.4275>
- Wicaksono, V. D., & Paksi, H. P. S. (2023). Google Sites as ICT Learning in Indonesia: The Benefits and Implementation. *KnE Social Sciences*, 8(8). <https://doi.org/10.18502/kss.v8i8.13303>