# Development of an E-Learning System to Support Informatics Learning at the Secondary School Level

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## ARTICLE INFO

## ABSTRACT

This study aimed to develop Google Sites-based e-learning media to improve digital literacy of high school students, especially in Informatics subjects at SMA Negeri 8 Malang. The study used a Research and Development (R&D) approach with the ADDIE (Analyse, Design, Development, Implementation, and Evaluation) development model. The results of the initial analysis showed low utilization of digital media in learning and limited supporting facilities. Based on these findings, interactive learning media was developed containing materials, quizzes, discussion forums, and digital learning resources. Validation by experts showed that the media was in the "Good" category (86.6%) and the digital literacy instrument was in the "Very Good" category (92.5%), with high reliability ($\alpha = 0.823$). Implementation was carried out on grade X students with a flipped classroom and blended learning approach. The evaluation results showed a significant increase in students' digital literacy, indicated by a pre-test score of 19.78 and a post-test score of 41.19, with a significance value (p) of 0.000 (<0.05). The N-Gain value of 0.70 falls into the "High" category. These findings indicate that Google Sites-based e-learning media is effective in improving digital literacy and providing interactive learning experiences relevant to 21st-century needs. This study recommends strengthening teacher training and developing infrastructure to support the sustainability of e-learning in schools.

1. **Introduction**

   The development of information and communication technology (ICT) has brought fundamental changes to various aspects of life, including education. The digital era demands learning that is not only based on conventional face-to-face learning but also adaptive to technology. One implementation of this transformation is the implementation of an online learning system, or e-learning. This system utilizes digital devices and internet networks to enable the teaching and learning process to take place without being bound by the constraints of space and time. The existence of e-learning has proven to provide flexibility in learning, expand access to learning resources, and encourage the creation of a collaborative and digitally integrated education ecosystem. The need for technology utilization in education has intensified following the COVID-19 pandemic. During this period, online learning has become the primary solution for maintaining the continuity of teaching and learning activities. The use of platforms such as Google Classroom, Google Sites, and other Learning Management Systems (LMS) has increased significantly. In the context of 21st-century learning, these systems also support the development of digital literacy, namely the skills to access, evaluate, and use information wisely in the digital space. However, the low digital literacy index in Indonesia, which only reached 3.54 (Ministry of Communication and Information Technology & Katadata Insight Center, 2022), indicates that the challenge of mastering technology remains quite significant among students and educators.
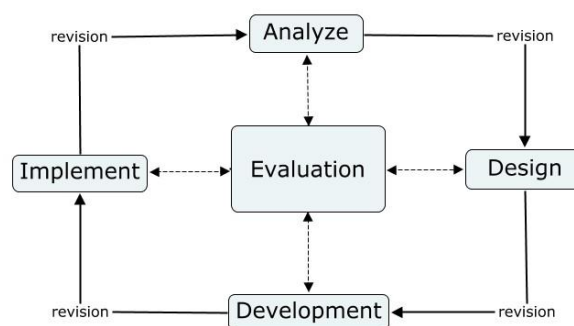
   This reality is exacerbated by limited facilities and the suboptimal use of digital media in learning in a number of schools. Many teachers still rely on conventional methods and printed textbooks and are not yet fully capable of developing digital learning media appropriate to the characteristics of the subject. Observations conducted at SMA Negeri 8 Malang showed that Informatics, which should be based on practice and computational thinking, is still dominated by textual delivery. Furthermore, limited resources, such as computers and projectors, which are used in rotation between classes, also hinder the optimal implementation of e-learning. Yet, several studies have shown that technology integration in Informatics learning can increase student participation and learning outcomes. Pratama and Kusuma (2021) demonstrated that the use of an LMS such as Moodle has a positive impact on flexible and effective learning structures. Helianak and Surjono (2021) also found that e-learning can improve student learning outcomes in Information and Communication Technology (ICT) subjects. Even the e-learning-based Problem-Based Learning (PBL) approach, as studied by Azizah (2021), is able to increase students' activeness and understanding of computer network material.

   However, developing e-learning is not sufficient simply by providing a digital platform. Interactive content design, ongoing teacher training, and adequate infrastructure support are also required. Teachers in the digital era must be able to act as innovative and creative learning facilitators, capable of designing learning experiences that are relevant to current developments (Sofiadin & Azuddin, 2021). Platforms like Google Sites are considered highly potential for development as digital learning media because they are free to access, easy to use, and support integration with various other Google products such as Google Docs, Google Forms, and YouTube. Based on these

conditions, the development of Google Sites-based Informatics learning media at SMA Negeri 8 Malang is crucial. This media not only provides a modern and contextual learning alternative but can also be a means of improving students' digital literacy. Furthermore, the development of Google Sites-based e-learning is expected to encourage teachers to be more creative and adaptive in creating an interactive and meaningful learning environment. With the right pedagogical approach such as flipped classroom, project-based learning, and experiential learning, this online learning system is expected to be a long-term solution in improving the quality of Informatics education in the era of Industrial Revolution 4.0 and society 5.0.

## 2.  Method

This research uses a Research and Development (R&D) approach, adopting the ADDIE (Analyse, Design, Development, Implementation, and Evaluation) model. The ADDIE model is a widely used framework in learning product development due to its systematic and structured nature, enabling researchers to produce effective and tailored learning media (Hidayah & Purnomo, 2022; Rahmawati et al., 2023).



**Figure 1. ADDIE Model**

The Analysis stage was conducted to identify the needs and constraints in Informatics learning at SMA Negeri 8 Malang, particularly regarding the integration of digital technology. The Design stage involved designing interactive, easily accessible Google Sites-based e-learning media that supports various types of digital content (Putri et al., 2021). The Development stage focused on creating and testing the learning media before its widespread implementation. Next, the Implementation stage involved implementing the learning media in online classroom learning, followed by the Evaluation stage, which aimed to assess the effectiveness of the media's use through the collection of quantitative and qualitative data, such as students' digital literacy levels, participation, and learning outcomes (Sari & Wibowo, 2022).

Data collection was conducted using a survey method using questionnaires and practical tests to obtain a comprehensive overview of the impact of using this digital learning media. The data obtained were analyzed descriptively to describe students' digital literacy levels and the media's effectiveness in supporting the learning process (Nugroho & Prasetya, 2023).

This R&D approach with the ADDIE model is expected to produce adaptive and innovative online learning media, as well as become a learning solution that is relevant to

the demands of 21st-century education, especially in facing the challenges of digital transformation after the COVID-19 pandemic (Wijayanti et al., 2021).

## 2.1 Development Stage

The learning media development procedure in this study used the ADDIE model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation. The following explains each stage:

### a) Analyze

At this stage, researchers conducted a needs analysis to identify problems and potentials in the Informatics learning process, as well as students' digital literacy levels. Data collection was conducted through interviews with the principal, Informatics teachers, and homeroom teachers, as well as focus group discussions (FGDs) with several students at SMA Negeri 8 Malang. The analysis results revealed limited digital resources, a lack of interactive content, and low digital literacy skills in online learning. This formed the basis for developing learning media that meet the needs of students and teachers.

### b) Design

Based on the analysis results, the researchers developed a web-based interactive learning media design using Google Sites. At this stage, the researchers designed the site's navigation flow, page structure, and content integrated with interactive features. The developed materials covered topics in Informatics and were supported by multimedia elements to increase student engagement. Furthermore, the researchers also designed pages for interactive quizzes (Quizizz), online discussions, assignment submission, and links to learning videos.

### c) Development

At this stage, the learning media is developed entirely using the Google Sites platform via sites.google.com. The media created includes several main pages, namely:

- Home Page
- Materials Page
- Quiz Page (Quizizz)
- Assignment Submission Page
- Discussion Page
- Additional Resources Page (eBooks & Videos)

Researchers also developed a digital literacy questionnaire to measure the effectiveness of media in improving students' digital literacy. The questionnaire addressed five key indicators of digital literacy: information, communication, content creation, safety, and problem-solving, with a total of 10 items. All media and instruments were validated by media and content experts.

### 1) Media Validation Instrument

This instrument is used to assess the suitability of learning media based on five aspects, as presented in the following table:

**Table 1.** Media Validation Instrument Grid

| No. | Assessment Aspects | No. Item | Number of Items |
|-----|--------------------|----------|-----------------|
| 1 | Layout Design | 1, 2, 3 | 3 Items |
| 2 | Teks | 4, 5, 6 | 3 Items |
| 3 | Images and Video | 7, 8, 9, 10 | 4 Items |

| 4 | Language | 11, 12, 13 | 3 Items |
| 5 | Usage | 14, 15 | 2 Items |
| | **Total** | | **15  Items** |

### 2)  Digital Literacy Questionnaire Validation Instrument

This assessment instrument consists of ten items, each of which will be assessed for its relevance to digital literacy. The following outlines the digital literacy questionnaire assessment instrument:

**Table 2.** Digital Literacy Questionnaire Validation Instrument Grid

| No. | Digital Literacy Indicators | No. Item | Number of Items |
|---|---|---|---|
| 1 | Information | 1, 2, 3 | 3 Items |
| 2 | Communication | 4, 5 | 2 Items |
| 3 | Content Creation | 6, 7 | 2 Items |
| 4 | Safety | 8, 9 | 2 Items |
| 5 | Problem-solving | 10 | 1 Items |
| | **Total** | | **10  Items** |

### d)  Implementation

The expert-validated learning media was then implemented in the Informatics subject in two classes at SMA Negeri 8 Malang in the even semester of the 2024/2025 academic year. Implementation took place in classrooms and computer laboratories. Prior to using the media, students were given a pre-test questionnaire to assess their initial digital literacy. Teachers received brief training on media use, and the learning process utilized a blended learning approach with a flipped classroom model.

### e)  Evaluation

The evaluation phase is conducted to assess the effectiveness of learning media in improving students' digital literacy. Evaluation takes two forms:

1) **Formative Evaluation**: conducted during the implementation process through classroom observations and teacher reflection notes.
2) **Summative Evaluation**: conducted by comparing the results of students' digital literacy **pre-tests** and **post-tests**, as well as distributing questionnaires assessing satisfaction with media use.

Data were analysed quantitatively using descriptive statistics and paired-sample t-tests, as well as qualitatively through thematic analysis of interviews and open-ended responses. This evaluation aimed to ensure that the developed media were pedagogically, technically, and contextually appropriate for Informatics learning at the high school level.

## 2.2 Research Instruments

An instrument is a tool used to measure research variables objectively and systematically. The purpose of using this instrument is to obtain accurate and comprehensive data to evaluate the effectiveness of the developed learning media.

This questionnaire was used during the pre-test and post-test to measure changes in the digital literacy levels of 10th-grade students at SMA Negeri 8 Malang after participating in e-learning-based learning.

**Table 3.** Digital Literacy Questionnaire Grid for Students

| Indicator | Statement |
|---|---|
| Information | 1. I can search for and access information independently via the internet. |
| | 2. I understand how to type and open website addresses correctly. |
| | 3. I am able to download learning documents from digital platforms. |
| Communication | 4. I can discuss and provide comments via digital forums. |
| | 5. I can share files or information with friends online. |
| Content Creation | 6. I understand how to use the features on digital learning platforms. |
| | 7. I understand the importance of copyright in creating and using content. |
| Safety | 8. I am careful when sharing personal information online. |
| | 9. I use polite and clear language when communicating digitally. |
| Problem Solving | 10. I can use digital technology to complete school assignments. |

## 2.3 Data Collection Techniques

Data collection in this study was conducted using several complementary techniques to obtain comprehensive information regarding the development and effectiveness of Google Sites-based e-learning media. The techniques used included interviews, observation, documentation, and questionnaires.

a) Interview

Semi-structured interviews were conducted with the principal, Informatics teacher, homeroom teacher, and several 10th-grade students at SMA Negeri 8 Malang. The purpose of these interviews was to gain in-depth information regarding the need for digital-based learning, students' digital literacy levels, and expectations for the learning media to be developed. The results of these interviews were also used to strengthen and supplement the data obtained through the questionnaire.

b) Observation

Observations were conducted directly during the learning process, both before and during the implementation of the learning media. These observations aimed to observe student activities in using digital media, their level of engagement in the learning process, and teacher responses to the use of the developed e-learning media. Researchers used observation sheets as instruments for recording data in the field.

c) Documentation

Documentation techniques were used to collect various physical and digital evidence related to the research process. The collected documentation included photographs of learning activities, screenshots of learning media displays, videos of implementation, and student work results. This documentation served not only as supporting evidence but also as a supplementary data source for qualitative analysis.

d) Questionnaire

A questionnaire was used as the primary instrument for quantitative data collection. It was administered to students before and after using the learning media to measure their digital literacy levels. The questionnaire used was a closed-ended questionnaire, with statements structured based on digital literacy indicators. The questionnaire was filled out using a four-point Likert scale, which measures the extent to which students agree or disagree with the statements. The questionnaire instrument was validated by experts to ensure clarity, indicator suitability, and reliability as a measuring tool.

**2.4 Data Analysis Techniques**

This study used a mixed approach involving quantitative and qualitative data to gain a comprehensive understanding of the development and effectiveness of Google Sites-based e-learning media in improving students' digital literacy at SMA Negeri 8 Malang. Quantitative data were obtained from media validation questionnaires conducted by expert lecturers, digital literacy indicator validation questionnaires, student pre- and post-test questionnaires, and digital literacy practice test assessments. The data were analyzed using descriptive and inferential statistics with the aid of IBM SPSS version 27 software.

To assess the validity of the developed learning media, questionnaires were distributed to expert validators on a scoring scale of 1 to 5. The obtained scores were calculated as a percentage by dividing the obtained score by the maximum score and then multiplying by 100%. These percentages were then interpreted in terms of eligibility criteria, ranging from "Very Good" to "Poor." Furthermore, validation of the digital literacy questionnaire instrument was also carried out by experts using a Likert scale of 1 to 4. The calculation and interpretation procedures for the results were similar to media validation, and were used to determine the extent to which the indicators in the questionnaire were in accordance with the aspects of digital literacy being studied.

After the instrument was validated, the validity of the digital literacy questionnaire items was tested using the Pearson Product Moment correlation technique in SPSS. This test aimed to determine whether each statement in the questionnaire had a significant relationship with the total score. An item was considered valid if the significance value obtained was less than 0.05. Furthermore, the instrument's reliability was also tested using the Cronbach Alpha method. The instrument was deemed sufficiently reliable if the alpha value was above 0.6, and the higher the alpha value (closer to 1), the higher the reliability.

**2.4.1  *Result of Instrument* Validation and Reliability**

a) *Validity Test*

The validity test was conducted on the questionnaire and pretest-posttest instruments using SPSS version 25. The instrument validity was assessed by checking the significance value (Sig. 2-tailed) and comparing the calculated r-value ($r_{count}$) with the critical r-value ($r_{table}$) at a 5% significance level ($\alpha = 0.05$).

Based on the analysis results, the Sig. (2-tailed) values for all items in both variable X (use of e-learning) and variable Y (learning outcomes) were found to be less than 0.05. Moreover, all $r_{count}$ values exceeded the $r_{table}$ value. With a total of 25 respondents, the degrees of freedom (df) = N - 2 = 23, which gives an $r_{table}$ of 0.3365.

Since all $r_{count}$ > $r_{table}$ and Sig. < 0.05, it can be concluded that each item of the instrument is valid and suitable for further analysis.

b) *Reliability Test*

The reliability of the instrument was tested using Cronbach's Alpha in SPSS. According to Sugiyono (2021), a reliability coefficient is considered acceptable if $\alpha > 0.70$. The reliability results for several indicators are summarized in Table 1 below.

**Table 4.** Summary of Instrument Reliability

| *Indicators* | *Result A* | *Result B* | *Implication* |
|---|---|---|---|

| Analysis 1 | 1 | 5 | Valid |
|---|---|---|---|
| Analysis 2 | 2 | 6 | Valid |
| Analysis 3 | 3 | 7 | Valid |
| Analysis 4 | 4 | 8 | Valid |
| Total | 10 | 26 | |

The digital literacy practice test was assessed based on a rubric developed from digital literacy indicators. Each student was assessed with a score range of 1 to 5, which was then classified into categories such as *"Very Good," "Good," "Fair,"* and so on, to determine their final abilities after using the learning media. Furthermore, the results of the pre-test and post-test questionnaires on student digital literacy were analyzed to determine any changes or improvements after using the media. Each item in the questionnaire uses a Likert scale of 1 to 5, ranging from "Strongly Disagree" to "Strongly Agree." After the data was collected, a normality test was performed using the Shapiro-Wilk test to determine whether the data were normally distributed. Data were considered normally distributed if the significance value was greater than 0.05.

If the data is normally distributed, a paired sample t-test is conducted to compare digital literacy scores before and after media use. This test aims to determine whether there is a significant difference between the two data groups. If the significance value (p-value) obtained is less than 0.05, it can be concluded that the use of e-learning media has a significant impact on improving students' digital literacy. In addition, an N-Gain analysis is also conducted to measure the effectiveness of improving digital literacy skills. The N-Gain formula calculates the difference between the post-test and pre-test scores, then divided by the difference between the ideal score and the pre-test score. The results of the N-Gain calculation are then categorized into three levels: high (if $g > 0.7$), medium ($0.3 \leq g \leq 0.7$), and low (if $g < 0.3$).

Meanwhile, qualitative data came from interviews, observations, and documentation collected during the development and implementation of the learning media. This data was analyzed using thematic analysis. The analysis stages included transcription of interview results and field notes, theme identification, data coding, and interpretation based on relevant findings. This analysis aimed to strengthen the quantitative results and provide a deeper understanding of the context and user perceptions of the developed learning media. With comprehensive data analysis, both quantitative and qualitative, this study is expected to provide a complete picture of the effectiveness and relevance of using Google Sites-based e-learning media in improving students' digital literacy at SMA Negeri 8 Malang.

## 3. Results

This research is the development of e-learning media using Google Sites, which aims to improve the digital literacy of high school students. The learning media is designed to enable students to better understand and hone their digital literacy skills in a meaningful, structured, and interactive manner. This research uses a Research and Development (R&D) approach with the ADDIE development model consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. The following are the results of each stage of media development that has been implemented at SMA Negeri 8 Malang:

### 3.1 Analyze Stage

This stage is the initial step in the development process. Data were collected through interviews with the principal, ICT teachers, and several 10th-grade students. Based on the interviews, it was discovered that the learning process for ICT and other subjects at SMA

Negeri 8 Malang is still dominated by the use of printed textbooks. Although facilities such as projectors and computer laboratories are available, their utilization is not optimal, and the use of digital media in learning is still limited to playing learning videos from YouTube.

Some interview quotes that support these findings are as follows:

**Researcher**: *"How do you see the level of digital literacy at this school?"*

**Principal**: *"Generally, it's quite good, because students are accustomed to using digital media wisely. We have a computer lab, but not all classes can use it regularly due to limited equipment."*

**Researcher**: *"How do you assess the digital literacy skills of the students in your class?"*

**ICT Teacher**: *"We have tried to provide a basic understanding of technology use, but in practice, not all students are able to utilize digital media optimally due to a lack of structured practice."*

**Researcher**: *"Do you prefer learning from books or using digital media?"*

**Student**: *"It's more fun using digital media, especially if there are videos, quizzes, or links you can open yourself. It helps you understand better and you don't get bored."*

Based on these findings, researchers concluded the need for innovative, more interactive and accessible digital learning media. Google Sites-based e-learning media was developed as a solution to provide an engaging learning experience while simultaneously supporting students' digital literacy development.

### 3.2 Design Stage

At this stage, researchers carry out media design which includes the following activities:

**a)  Material and Content Design**

The material to be included in Google Sites covers subjects that support digital literacy development, such as Informatics, Indonesian, and Pancasila Education. The content consists of summarized text, images, and instructional videos taken from trusted sources like YouTube and official education websites.

**b)  Website Display Design**

The media was developed in the form of an interactive website using the Google Sites platform, designed with an attractive appearance and easy navigation. Researchers created a main homepage as well as dedicated pages for materials, quizzes (using Quizizz), discussions, and digital book download links.

**c)  Design of Evaluation Instruments**

To measure the media's success, researchers developed a digital literacy questionnaire and practical tests. The instruments were based on five digital literacy indicators: information, communication, content creation, safety, and problem-solving.

### 3.3 Development Stage

This stage includes developing media products and developing evaluation instruments. The Google Sites website is designed with various features, such as:

**a)  Materials Page:** Presents learning content from various subjects with links to videos, images, and text summaries.

**b)  Quizizz Page:** Provides links to interactive quizzes that students can take online.

**c)  Discussion Page:** Provides a forum for students to discuss and share their understanding.

**d)  Downloads Page:** Contains download links for relevant digital books.

Apart from media development, researchers also created two types of instruments, namely:

a)  Media validation instrument, consisting of 5 assessment scales.

b)  Digital literacy questionnaire instrument, with a rating scale of 1–4.

After the media and instruments were developed, **validation** was conducted by expert lecturers. The media validation results yielded an average score of 86.6, which falls into the "Good" category, while the digital literacy instrument received an average score of 92.5, which falls into the "Very Good" category.

Next, the validity of the digital literacy questionnaire was tested using Pearson Product Moment correlation. The results showed that all items had a significance value <0.05, indicating validity. The reliability test using Cronbach's Alpha yielded a value of 0.823, indicating the instrument is highly reliable.

The media was then revised based on input from the validator, including: improving the appearance of photos, sentence structure, adjusting images, and adding relevant digital books.

### 3.4 Implementation Stage

After the media met the "Good" criteria, it was implemented with 10th-grade students at SMA Negeri 8 Malang. The program took place over five days in the computer lab and classrooms. Before starting the lesson, students completed a questionnaire assessing their initial digital literacy skills. During implementation, researchers facilitated the use of the media and guided students in accessing content, reading materials, and taking digital quizzes.

Students were also given access to websites from their personal devices at home to expand their independent learning process and prepare them for final semester exams.

### 3.5 Evaluation Stage

This stage aims to determine whether the use of Google Sites-based e-learning media is effective in improving the digital literacy of class X students at SMA Negeri 8 Malang.

Evaluation is done by comparing:

a)  **Pre-test** results, which are questionnaires assessing students' initial digital literacy skills, completed before using the media.

b)  **Post-test** results, which are practical digital literacy tests, conducted after students use the e-learning media.

### 3.6 Descriptive Statistics

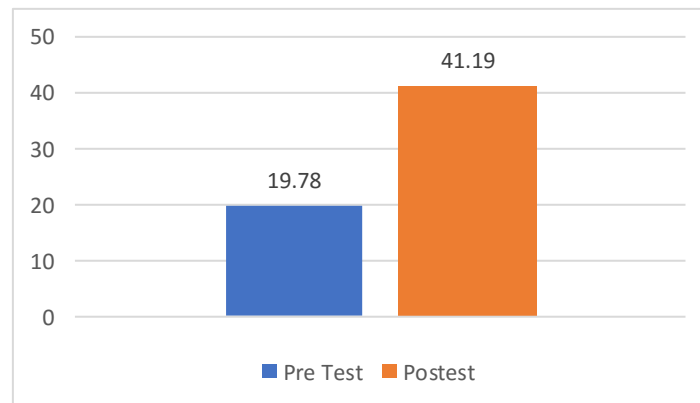Based on the evaluation results, the following data was obtained:

a)  **Pre-test Score**

Students achieved an average score of 19.78 on the maximum scale, indicating that their digital literacy skills prior to media use were still relatively low. This reflects limitations in digital communication, information retrieval, and skills in creating content safely and responsibly.

b)  **Post-test Score**

After five days of learning using Google Sites, digital literacy scores increased significantly, with an average score of 41.19. Students demonstrated improved abilities in:

1)  Navigate e-learning sites,
2)  Access and evaluate digital information,
3)  Participate in online quizzes,
4)  Download digital books,
5)  And engage in online discussions through the provided platforms.

**Fig 1.** Comparison of Pre-test and Post-test Average Scores

This graph shows a comparison of the average digital literacy scores of students before and after learning using Google Sites media for five days. It can be seen that the average pre-test score was 19.78, which indicates that the level of digital literacy skills of students was still relatively low at the beginning of the learning. After participating in the learning, there was a significant increase in the average post-test score, namely 41.19. This indicates an increase in digital literacy skills of students, especially in aspects of navigating e-learning sites, evaluating digital information, participating in online quizzes, downloading digital books, and online interactions through the platform used. This increase in scores indicates the effectiveness of Google Sites media as a learning tool in significantly improving students' digital literacy.

The descriptive statistical analysis was also conducted to obtain a general overview of the data, including the mean, median, minimum and maximum values, and standard deviation. The results of the descriptive statistical analysis of the pre-test and post-test data are presented in Table 5 below:

**Table 5.** Descriptive Statistics of Pre-test and Post-test

| Variabel | Mean | Median | Minimum | Maksimum | Standar Deviasi |
|---|---|---|---|---|---|
| Pre-test | 19,78 | 19 | 15 | 24 | 2,75 |
| Post-test | 41,19 | 41 | 37 | 45 | 2,96 |

The table shows an increase in the average and median scores from the pre-test to the post-test. The mean pre-test score of 19.78 increased to 41.19 in the post-test, while the median pre-test score of 19 increased to 41. This indicates an improvement in students' digital literacy skills after using Google Sites-based e-learning media.

This improvement is reflected not only in the average but also in the median, reflecting that more than half of the students had higher post-test scores than their pre-test scores.

### 3.7 Normality Test Pre-test and Post-test Normality Test

The initial step in this data analysis was to conduct a normality test on the pre-test and post-test scores to determine whether the data were normally distributed. Normal

distribution is a prerequisite for using parametric statistical tests, such as the paired t-test. Therefore, to determine the appropriate type of statistical test to analyze the differences between pre-test and post-test scores, a normality test was conducted using SPSS version 25.

In this study, the sample size was 30 students. Therefore, the Shapiro-Wilk test was used because this test is recommended for samples with sizes under 50. The results of the normality test on the pre-test and post-test data are shown in Table 6 below:

**Table 6.** Results of Pre-test and Post-test Normality Test

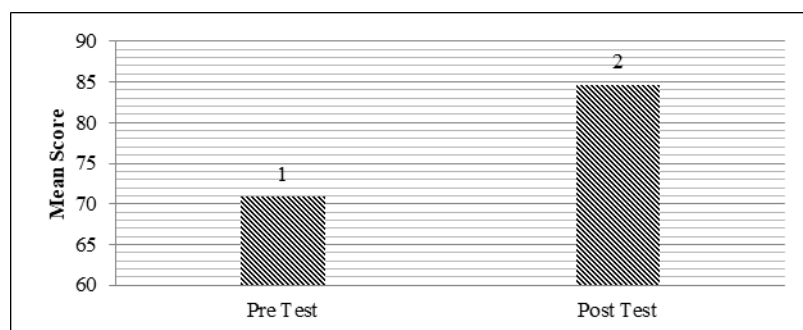| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistik | df | Sig. | Statistik | df | Sig. |
| Pre-test | 0,176 | 30 | 0,045 | 0,957 | 30 | 0,162 |
| Post-test | 0,143 | 30 | 0,089 | 0,974 | 30 | 0,312 |

Based on the table above, the Shapiro-Wilk test results for the pre-test scores yielded a significance value of 0.162, and for the post-test scores, a significance value of 0.312. Because both significance values are greater than the alpha limit of 0.05, it can be concluded that the pre-test and post-test data are normally distributed. With this normality assumption met, parametric statistical analysis, such as the paired t-test, can be used to analyze differences between students' pre-test and post-test scores.

### 3.8 Effectiveness of E-Learning Implementation

To evaluate the effectiveness of the developed e-learning system, a quasi-experimental method was applied using a pretest-posttest design. Students' learning outcomes before and after the implementation of the e-learning platform were analyzed to determine whether significant improvement occurred.

### 3.9 1 Paired Sample t-Test Results

The Sig. (2-tailed) value = 0.000 < 0.05, which indicates a statistically significant difference between the pretest and posttest scores. This result confirms that the e-learning system had a positive effect on students' learning outcomes.



**Fig. 2.** Paired Sample t-Test Results Pre- and Post Test

## 4  Discussion

The results of this study indicate that the development and implementation of Google Sites-based learning media significantly improved the digital literacy of 10th-grade students at SMA Negeri 8 Malang. This finding aligns with previous research highlighting the positive impact of

digital platform integration in learning, particularly in technology-related subjects such as Informatics (Pratama & Kusuma, 2021; Helianak & Surjono, 2021). The improvement in digital literacy is demonstrated through a comparison of pre-test scores (mean = 19.78) and post-test scores (mean = 41.19), which were statistically significant based on a paired sample t-test, validated by the use of parametric analysis through the Shapiro-Wilk normality test. This improvement was manifested in several key aspects, namely information navigation skills, communication, and digital content creation and security. Students demonstrated improved skills in boldly searching, accessing, and disseminating information, actively participating in online discussions and collaborations, and demonstrating a deeper understanding of digital ethics and copyright. This supports the view that 21st-century teachers need to act as creative learning facilitators with rich digital content (Sofiadin & Azuddin, 2021). The use of interactive features like Quizizz, digital books, and discussion forums in Google Sites encourages a more engaging and active learning process.

In terms of feasibility and effectiveness, the media validation results showed an average score of 86.6, which is included in the "good" category, covering aspects of design, content clarity, multimedia integration, and accessibility. Meanwhile, the digital literacy questionnaire obtained a validation score of 92.5 with high reliability (Cronbach's Alpha = 0.823), which strengthens the credibility of the measurement tool used in this study. Student responses to the use of digital media were also very positive, indicating enthusiasm and better understanding compared to conventional textbook-based learning methods. These findings reinforce the view that learning media must be adapted to the digital habits and preferences of today's generation of learners (Azizah, 2021).

This research also has important implications for future learning design. The Google Sites platform has proven to be a practical, affordable, and easy-to-develop platform, especially in schools with limited budgets. Blended learning models, particularly the flipped classroom approach, are effective in encouraging independent learning and improving students' digital competencies. Student-centre and interactive content has been shown to be more effective in building digital literacy than conventional, one-way, text-based methods. Therefore, the use of platforms like Google Sites should not only be implemented during crises like the COVID-19 pandemic, but should be considered as a long-term learning strategy. Adapting teaching materials to relevant digital skills, such as online research, secure communication, and content creation, will better prepare students for the demands of the 21st century, the Industrial Revolution 4.0 era, and Society 5.0.

However, this study has several limitations. The study was conducted in only one school with a small sample size (n = 30), so the results cannot be generalized. The short duration of media implementation (5 days) also hampers measuring the long-term impact on student retention and skill development. Furthermore, the media's primary focus was solely on digital literacy, while other 21st-century skills such as critical thinking, collaboration, and creativity were not explored in depth. Therefore, it is recommended that future research encompass a broader scale by involving several schools with diverse digital infrastructure conditions, extending the implementation duration to one semester or more, and integrating learning media with national curriculum standards and a comprehensive student assessment system.

## 5   Conclusion

The development and implementation of Google Sites-based learning media significantly improved the digital literacy of tenth-grade students at SMA Negeri 8 Malang. Expert validation of the media showed an average score of 86.6, categorized as "Good," while the digital literacy instrument received a validation score of 92.5 with high reliability (Cronbach's Alpha = 0.823),

confirming the reliability of the measurement tool. The evaluation results showed an improvement in students' digital literacy skills, as evidenced by an average pre-test score of 19.78 to 41.19 on the post-test after five days of using the media. This improvement included the ability to navigate e-learning sites, access and broadcast digital information, participate in online quizzes, download digital books, and interact in online discussion forums.

Google Sites-based learning media has proven effective in increasing student engagement and motivation due to interactive features such as digital quizzes and easily accessible learning resources. This aligns with the needs of 21st-century learning, which emphasizes the role of teachers as creative facilitators and the use of rich digital content.

However, this study has limitations, such as the sample size being limited to one school with 30 students and the implementation duration being only five days, which makes it impossible to measure long-term impacts. Furthermore, the developed media focused more on digital literacy and did not integrate other 21st-century skills such as critical thinking, collaboration, and creativity in depth. Therefore, it is recommended that further research be conducted on a broader scale, involving several schools and extending the implementation period to obtain a more comprehensive picture. Furthermore, integration of learning media with the national curriculum and a comprehensive assessment system is needed to optimally support the development of digital skills and student competencies.

## 6   Acknowledgments

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