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Development and Usability Evaluation of an Interactive Digital Literacy E-Module Based on Mayer's Multimedia Learning Principles for Phase E Students

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A B S T R A C T

High school students still face difficulties in distinguishing factual information from hoaxes in digital media, indicating the need for interactive learning media that can strengthen digital literacy skills. This study aimed to develop an interactive digital literacy e-module based on Mayer's multimedia learning principles and evaluate its usability using the System Usability Scale (SUS). The study employed a Design and Development Research (DDR) approach consisting of needs analysis, design, development, and evaluation stages. The e-module materials were designed using Canva by integrating text, images, and videos, while interactive questions and instant score feedback were provided through Google Sites. The usability evaluation involved 24 Phase E students who used the e-module during informatics learning activities. The results showed an average SUS score of 82.08, which falls into the Acceptable category, Grade A, and Excellent adjective rating. These findings indicate that the e-module was easy to use, comfortable, and well accepted by students. Therefore, the developed e-module can be considered a usable and appropriate learning medium to support digital literacy learning, particularly in helping students critically evaluate the accuracy of information.

1. Introduction

The rapid development of digital technology has significantly changed the way people access, produce, and disseminate information. Social media, search engines, and various digital platforms have become major sources of information for many groups, including high school students. This situation provides students with broad opportunities to obtain information quickly and independently. However, the same condition also creates new challenges because information in digital spaces is not always accurate, verified, or presented with clear accountability. The uncontrolled

circulation of information increases the potential spread of hoaxes, misinformation, and misleading content, especially among users who do not yet have adequate critical evaluation skills (Guess & Lyons, 2020). In this context, digital literacy is not merely related to the ability to operate digital devices, but also includes the ability to search, assess, evaluate, and verify information critically. Therefore, students need to develop digital literacy skills that enable them to identify credible sources, compare information from various references, and make reasoned judgments before accepting or sharing information in digital environments (van Laar et al., 2020).

In the educational context, digital literacy has become an important competency for Phase E students, particularly in informatics learning. Students at this level are actively exposed to digital media and frequently interact with online information in their daily lives (Islami et al., 2022). Nevertheless, several studies indicate that students still experience difficulties in distinguishing factual information from hoaxes and tend to rely on surface-level indicators, such as visual appearance, popularity, or emotional appeal, when judging the credibility of online content (Kurnia Fajarwati et al., 2023). This condition shows that digital literacy learning must be designed not only to introduce technological tools, but also to train students to think critically and evaluate the accuracy of information. In practice, learning activities in schools still often rely on conventional approaches, such as teacher explanations, printed materials, and limited discussion, which may not fully support students' active engagement in analyzing digital information. Conventional learning models may also provide fewer opportunities for students to interact with real cases, multimedia resources, and direct feedback that can help them understand the characteristics of misinformation more effectively (Rijal et al., 2021). If this issue is not addressed through appropriate learning media, students may become passive consumers of information and remain vulnerable to misleading content in digital spaces (Pennycook & Rand, 2021).

The development of interactive learning media is one possible strategy to support digital literacy learning more effectively. E-modules can present learning materials in flexible formats by combining text, images, videos, interactive questions, and feedback features. This format allows students to learn independently while still receiving guidance through structured content and learning activities (Wahyuni et al., 2025). Interactive e-modules are also relevant for informatics learning because they enable students to engage directly with digital content and practice evaluating information through contextual examples. In addition, multimedia-based learning can help students process information more clearly when verbal and visual elements are presented in a coordinated manner (Nurhikmah et al., 2021). Mayer's multimedia learning principles provide an instructional design foundation for organizing text, images, videos, and interactive elements so that learning materials can be understood more effectively and unnecessary cognitive load can be reduced. Through principles such as coherence, signaling, segmenting, and multimedia integration, learning content can be arranged in a more focused, meaningful, and student-friendly way (Hasibuan et al., 2023). Therefore, applying Mayer's principles in an interactive digital literacy e-module is expected to support students'

engagement and understanding when learning about factual information, hoaxes, and information verification (Diens et al., 2026).

Although many studies have discussed digital learning media, not all of them have systematically integrated multimedia learning principles with usability evaluation. In digital learning media development, usability is an important aspect because a learning product that is visually attractive does not automatically guarantee ease of use, comfort, or user acceptance (Wardhani et al., 2025). Students may experience difficulties if the navigation is unclear, the interface is inconsistent, or the interaction design requires excessive adaptation. Therefore, usability evaluation is needed to determine whether the developed e-module can be used efficiently, comfortably, and effectively from the users' perspective. The System Usability Scale (SUS) is one commonly used instrument to measure perceived usability because it provides a simple and practical way to assess user experience based on several aspects, including ease of use, consistency, confidence, and learnability (Mayer, 2020). In this study, SUS was used to evaluate students' perceptions after using the interactive digital literacy e-module. The use of SUS is important because the success of a digital learning medium is not only determined by the quality of its content, but also by how well students can access, navigate, and interact with the learning features provided (Fitrianingsih et al., 2025).

Based on these considerations, this study focuses on the development and usability evaluation of an interactive digital literacy e-module for Phase E students. The e-module was designed to address students' need for structured learning media that supports their ability to recognize factual information and hoaxes in digital media. The novelty of this study lies in the integration of Mayer's multimedia learning principles with systematic usability evaluation using SUS in the context of digital literacy learning for hoax prevention. By combining theory-based instructional design and user experience evaluation, this study provides a more comprehensive approach to developing digital learning media that is not only content-oriented, but also user-friendly and appropriate for students' learning needs. Therefore, this study aimed to develop an interactive digital literacy e-module based on Mayer's multimedia learning principles and evaluate its usability among Phase E students in informatics learning using the System Usability Scale.

2. Methodology

This study employed a Design and Development Research (DDR) approach to design and develop an interactive digital literacy e-module based on Mayer's multimedia learning principles and to evaluate its usability using the System Usability Scale (SUS). The DDR approach was selected because it enables the systematic integration of instructional media development and user experience evaluation. The participants of this study were 24 Phase E students at SMA PGRI 3 Purwakarta who used the interactive digital literacy e-module as end users during the implementation stage. In addition, curriculum teachers and informatics teachers were involved as validators to assess the content accuracy, curriculum relevance, readability, and interactivity of the developed e-module (Mayer, 2020).

Instruments

Several instruments were used in this study. The primary instrument was the interactive digital literacy e-module developed based on Mayer's multimedia learning principles. The e-module was created using Canva for designing text, images, and videos, while interactive activities, quizzes, and instant feedback features were integrated through Google Sites. The usability evaluation instrument consisted of a 10 item System Usability Scale (SUS) questionnaire developed by John Brooke. The questionnaire was used to measure students' perceptions regarding usability, efficiency, ease of use, and satisfaction after using the e-module (Mayer, 2020).

Data Collection

The research procedure consisted of four stages: needs analysis, design, development, and evaluation. The first stage was needs analysis, conducted through a literature review related to digital literacy and hoax prevention. The analysis revealed that students still experienced difficulties distinguishing factual information from hoaxes and often relied on visual appearance rather than source verification when assessing information credibility (Pennycook & Rand, 2021). These findings indicated the need for interactive learning media that support students' critical evaluation skills.

The second stage was the design process. At this stage, the e-module content, user interface, and multimedia elements were designed according to Mayer's multimedia learning principles. Part of the learning material was adapted from the "Benarkah Itu?" instructional module for Phase E students (Susanti, 2024). In addition, the material was also developed based on the learning objectives and topics outlined in the school syllabus to ensure curriculum alignment. The material was then transformed into an interactive format by integrating videos, case studies, reflective questions, and visual elements to increase student engagement and understanding.

The third stage was development. The e-module was developed using Canva and Google Sites to integrate multimedia content and interactive activities. After the initial product was completed, validation was conducted by curriculum teachers and informatics teachers to evaluate the accuracy, readability, curriculum alignment, and usability of the module. Feedback from the validators was used to revise and improve the e-module before implementation. The final stage was evaluation. The developed e-module was implemented in informatics learning activities for Phase E students. After using the e-module, students completed the SUS questionnaire to evaluate the usability and learning experience of the module.

Data Analysis

The collected data were analyzed quantitatively using the System Usability Scale (SUS). SUS scores were calculated using the following formula:

$$SUS\ Score = (\sum(R_i - 1)_{odd} + \sum(5 - R_i)_{even}) \times 2.5$$

The obtained scores were interpreted using acceptability ranges, grade scales, and adjective ratings to determine the usability level of the interactive digital literacy e-module. Descriptive statistical analysis, including mean, median, minimum score, maximum score, and standard deviation, was also conducted to identify students' overall perceptions of the developed e-module.

3. Results and Discussion

This study aimed to develop and evaluate an interactive digital literacy e-module based on Mayer's multimedia learning principles for Phase E students. The e-module was implemented in informatics learning activities, and students were asked to evaluate its usability using the System Usability Scale (SUS). A total of 24 students completed the evaluation questionnaire, resulting in a 100% response rate. This indicates that all collected data fully represented students' experiences while using the interactive e-module (Pennycook et al., 2021).

The developed e-module integrated various multimedia elements, including text, images, videos, interactive quizzes, and reflective activities. These elements were designed based on Mayer's multimedia learning principles to support students' understanding and engagement during the learning process. The module also provided instant feedback through interactive activities integrated into Google Sites, allowing students to evaluate their understanding directly after completing each task (Abdurrahman et al., 2025; Nurhikmah et al., 2021). The developed interactive e-module integrated text, images, and visual explanations to help students understand fact information and hoaxes more clearly. The display of the learning material contained in the e-module can be seen in Figure 1.

Figure 1. Interactive E-Module Material

To increase students' engagement during the learning process, the e-module also included animated videos containing contextual explanations related to digital literacy materials. In addition, students were asked to complete reflective questions through the provided link as a form of evaluating their understanding of the learning materials. The implementation of the animated video feature and students' reflective activities is presented in Figure 2.

Figure 2. Animated Video

To encourage students' critical thinking and evaluate their understanding of digital literacy materials, the developed e-module provided interactive case study activities and a final evaluation feature integrated into the learning process. Students were required to analyze information through videos, answer reflective questions, and complete evaluation activities that provided instant scores and feedback. The implementation of these interactive features is presented in Figure 3.

Figures 1-3 indicate that the developed interactive e-module successfully integrated multimedia elements, including visual materials, animated videos, reflective activities, and interactive case studies to support students' engagement and understanding during digital literacy learning. These features encouraged students to participate actively in the learning process and helped them develop critical thinking skills in evaluating information credibility in digital media. Table 1 shows the results of the System Usability Scale (SUS) item analysis used to evaluate students' perceptions regarding the usability, ease of use, and effectiveness of the developed interactive e-module.

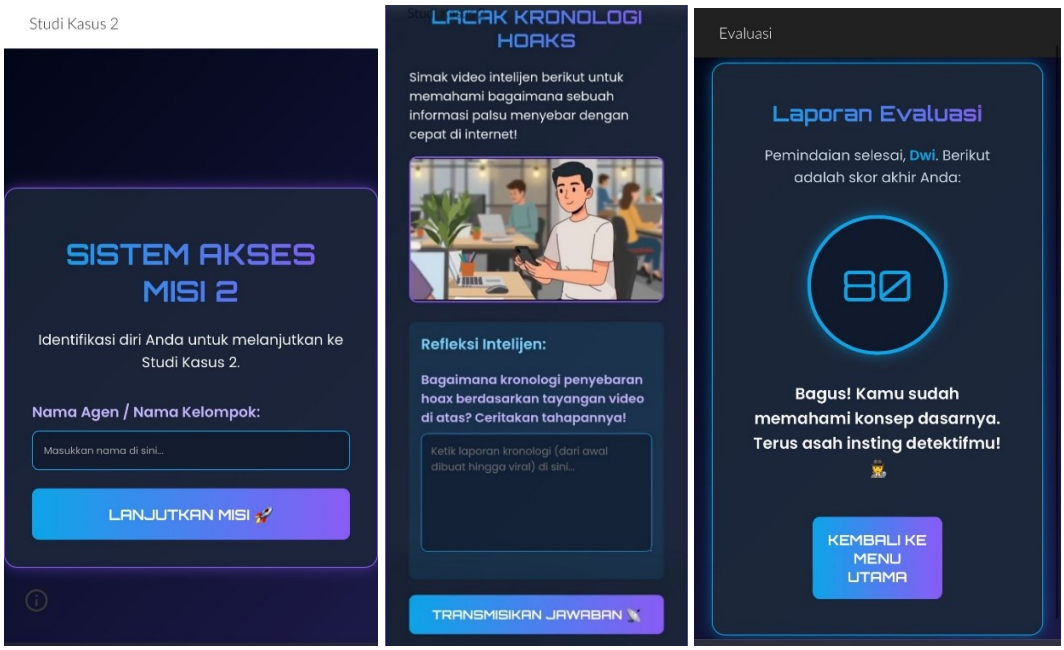

Figure 3. Interactive Activities and Evaluation Features in the E-Module

Table 1. SUS Item Scores

Item	Statement	Mean Score	Description
Q1 (+)	I would like to use this interactive e-module again in the future.	8.65	Most students agreed to use the module again.
Q2 (-)	I found the interactive e-module unnecessarily difficult to use.	7.81	The module was considered easy to use with low complexity.
Q3 (+)	I thought the interactive e-module was easy to use.	8.33	The module was perceived as very easy to use.
Q4 (-)	I needed assistance from others to use this e-module.	8.75	Students rarely required additional assistance.
Q5 (+)	The features in the interactive e-module functioned as expected.	8.54	The module features worked properly and were well integrated.
Q6 (-)	I found some inconsistencies in the e-module.	7.92	The module was considered consistent and uniform.
Q7 (+)	I believe other people could quickly learn to use this e-module.	8.44	The module was easy for new users to understand.
Q8 (-)	I found the module confusing to use.	8.33	The module was clear and not confusing.
Q9 (+)	I did not encounter significant obstacles while using the interactive e-module.	8.75	The module operated smoothly during use.
Q10 (-)	I needed time to become familiar with the e-module.	6.56	Students required slight adaptation time but still found it easy to learn.

The results in Table 1 indicate that most students positively evaluated the usability of the interactive e-module. The highest scores were obtained for items related to ease of use and the absence of major obstacles during implementation. These findings suggest that the module had an intuitive design and was easy for students to operate independently. Although several students required a short adaptation period, the module was still considered understandable and user-friendly. Table 2 presents the descriptive statistical results of the System Usability Scale (SUS) scores obtained from students after using the interactive digital literacy e-module.

Table 2. Descriptive Statistics of SUS Scores

Statistics	Value
Number of Respondents	24
Minimum Score	67.5
Maximum Score	92.5
Mean	82.08
Median	83.75
Standard Deviation	6.66
Grade	A
Adjective Rating	Excellent
Acceptability	Acceptable

The average SUS score of 82.08 indicates that the interactive e-module is considered very suitable for use. The median and standard deviation values confirm that student perceptions are consistent, while the minimum and maximum scores indicate that all respondents gave positive to very high ratings. Interpretation of the (Bangor et al., 2009) scale places the module in the Acceptable, Grade A, and Adjective Rating Excellent categories, confirming that the module is able to provide a comfortable, efficient, and satisfying learning experience. This high score also indicates that student interaction with the e-module is positive and adequate to support understanding of digital literacy materials. Table 3 presents the distribution of students' responses toward the usability and overall learning experience of the developed interactive digital literacy e-module after its implementation in informatics learning activities.

Table 3. Distribution of Student Responses

Category	Number of Respondents	Percentage
Very Good	16	66.67%
Good	7	29.17%
Fair	1	4.17%

The table above shows that the majority of students rated the e-module as Very Good, while only one student rated it as "Fair," indicating that most participants had a positive experience. The success of this module is related to the application of Mayer's multimedia principles, where the combination of text, images, videos, and interactive activities enhances student engagement and understanding. The

principle of coherence ensures only relevant information is presented, signaling highlights important points, and segmenting breaks down the material for easy comprehension. Interactive activities and video case studies encourage students to think critically and actively evaluate information, making this interactive e-module effective in supporting digital literacy. Validation by curriculum teachers and informatics teachers ensures the content is accurate and curriculum-aligned, while a high SUS score confirms the module's suitability for widespread use (Wardhani et al., 2025).

4. Conclusion

This study concluded that the interactive digital literacy e-module based on Mayer's multimedia learning principles was successfully developed as a usable learning medium for Phase E students in informatics learning. The e-module was designed by integrating text, images, videos, interactive questions, case-based activities, and instant feedback to support students in learning digital literacy, particularly in distinguishing factual information from hoaxes. The development process showed that multimedia elements could be organized in a structured way to make the learning content clearer, more engaging, and easier for students to follow.

The usability evaluation indicated that the e-module was well accepted by students. Students perceived the module as easy to use, comfortable, consistent, and helpful during the learning process. This finding answers the research objective by showing that the developed e-module met the usability expectations of its users. The success of this study can be seen from the positive student responses and the validation results from curriculum and informatics teachers, which confirmed that the content was appropriate, understandable, and aligned with the learning objectives.

However, this study also has limitations. The evaluation focused on usability and user acceptance, so it has not yet measured the direct impact of the e-module on students' learning achievement or critical thinking skills. Therefore, the developed e-module can be considered suitable for supporting digital literacy learning, but further research is needed to examine its effectiveness in improving students' ability to evaluate information accuracy in broader learning contexts.

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