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Development of Interactive E-Modules for Literacy Courses in Physics Learning Assisted by Google Sites to Improve Students' Problem-Solving Skills

Dea Stivani Suherman[1*], Fuja Novitra[1], Rani Oktavia[2], Hayyu Yumna[1], Asrizal[1]

[1] Department of Physics, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia.
[2] Department of Science Education, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia.

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Corresponding Author:
Dea Stivani Suherman
deastivani@fip.unp.ac.id

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Abstract: This study aims to determine the needs analysis, validity, and limited practicality of interactive e-modules assisted by Google Sites to improve problem-solving skills in literacy courses in physics learning. The study adopts a development approach grounded in the Plomp model. The data were then analyzed using descriptive statistical analysis techniques. The needs analysis shows low problem-solving skills and a lack of contextual teaching materials, thus requiring the development of more innovative e-modules. The analysis results also show that the characteristics of the students are in the good category, thus supporting the implementation of these teaching materials. The validity of the developed interactive e-module reached 0.86, indicating that the e-module is valid. The average practicality score was 0.70, which falls into the practical category. These results indicate that the interactive e-module developed is necessary, valid, and practical. These findings confirm that the e-module has met the quality criteria for development, making it suitable for use in learning and ready to proceed to the effectiveness testing stage to assess its potential in improving students' problem-solving skills.

Keywords: Google sites; Interactive e-module; Problem solving skills

Introduction

Advances in 21st-century technology have triggered major changes, especially in the field of education. Education is required to equip students with 21st-century skills (Bhardwaj et al., 2025; Celik et al., 2024; Herlinawati et al., 2024; Thornhill-miller et al., 2023; Wulandari et al., 2021). Problem-solving skills are one of the important 21st-century skills to master. This skill is closely related to higher-order thinking skills in analyzing and solving real-world problems based on scientific concepts (Babaoğlu & Yıldırım, 2023; Lutvita et al., 2020; Wahyudi et al., 2022; Zulfah et al., 2022). Problem-solving skills involve critical (Azizah et al., 2025; Doyan et al., 2025), creative, and analytical thinking processes to find solutions to complex problems (Alberida et al., 2022; Rusmin et al., 2024; Susetyarini et al., 2022). These abilities are a fundamental foundation for facing global and technological challenges (Lu et al., 2021; Putri & Usmeldi, 2023; Shamsuddin et al., 2025; Yanuarto et al., 2023). Therefore, learning models and media need to be adapted to the characteristics of today's students.

The use of technology in learning is a key factor in supporting 21st century learning. Digital technology plays a role in providing more flexible access to learning, delivering interactive media, enabling rapid feedback, and supporting adaptive and engaging learning material management (Narulita et al., 2024; Yaseen et al., 2025; Zou et al., 2025). The use of interactive digital

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technology provides opportunities for students to actively participate in exploring concepts, conducting virtual experiments, and reflecting on learning outcomes (Pan et al., 2024; Yaseen et al., 2025). Digital-based learning media such as e-modules, interactive videos, and web-based learning platforms have been proven to improve 21st-century skills (Alghamdi, 2025; Delita et al., 2022; Dewi & Mercuriani, 2024; Pan et al., 2024).

One course that plays an important role in developing problem-solving skills is the course on literacy in physics education. This course aims to develop students' ability to understand, interpret, and apply physics concepts to real-life contexts through a science and technology literacy approach (Indrasari, 2025; Sari et al., 2025). Students are not only required to understand theory, but also to analyze scientific information from various sources, integrate concepts, and design science-based solutions to physics problems encountered in the real world (Baran-Bulut & Yüksel, 2023; Wang et al., 2025). Therefore, the success of learning in this course is highly dependent on learning media and strategies that can stimulate active engagement and problem-solving skills among students.

The main problem in this study is the low problem-solving ability of students. Based on the results of a preliminary study, the average problem-solving ability of students is 67.80, which is classified as low, in line with previous research findings that show that students' problem-solving abilities are indeed still low (Asih et al., 2022; Ayunda et al., 2024a; Bahtiar et al., 2022). Students also often have difficulty understanding contextual physics problems, formulating hypotheses, and developing systematic solution steps (Evendi et al., 2024; Qotrunnada, 2022). In addition, the teaching materials used are still conventional, in the form of printed books or simple e-books that do not facilitate interaction, reflection, and problem-solving-oriented activities. Therefore, more interactive and adaptive solutions are needed to overcome these problems, one of which is through the development of interactive e-modules based on Google Sites. However, the solutions available in previous studies are not yet fully relevant to the context of lectures.

Several previous studies have developed interactive e-modules. Previous studies on problem-solving-based e-modules (Khuzaimah et al., 2022; Widya, Ginting, et al., 2023), Google Sites-based e-modules (Waraga et al., 2023; Wulansari et al., 2025), and e-modules integrated with learning approaches and models (Marta et al., 2025; Nazifah & Asrizal, 2022; Rahmayani & Asrizal, 2024). However, most of these studies focused on secondary school levels and did not specifically integrate the Google Sites platform with a problem-solving orientation in the context of university-level physics learning. This condition indicates a research gap that needs to be filled through the development of digital learning media that is relevant to the characteristics of students and the demands of 21st-century learning. Therefore, the purpose of this study is to determine the needs analysis, validity, and limited practicality of interactive e-modules in physics literacy courses assisted by Google Sites to improve students' problem-solving skills.

To support the achievement of research objectives, it is necessary to utilize technological innovations in the development of teaching materials, particularly through interactive electronic modules. The development of digital technology has given rise to various forms of electronic teaching materials that are more adaptive and flexible (H et al., 2021; Kyriacou et al., 2024; Lasala, 2023). Interactive e-modules enable the integration of text, images, videos, simulations, and quizzes that promote meaningful learning experiences (Andriani et al., 2021; Ayunda et al., 2024b; Rahmatsyah & Dwiningsih, 2021). Previous studies have shown that interactive e-modules are effective in improving literacy, learning motivation, and 21st-century skills (Asrizal et al., 2025; Fitri et al., 2024; Muliyadi et al., 2023; Nazifah & Asrizal, 2022; Rahmayani & Asrizal, 2024).

The use of technology such as Google Sites is an attractive alternative for developing interactive e-modules. Google Sites has many features and functionalities that can also be hyperlinked to all other online-based media or technologies (Kurniawan et al., 2024; Mulya et al., 2024; Wirdatul Izzah et al., 2024). Google sites can be used to create interactive teaching materials that contain many elements such as videos, audio, animations, and games that can facilitate learning (Komariah et al., 2024; Wirdatul Izzah et al., 2024). Google Sites is also easy to access, supports collaboration, and can be integrated with various multimedia content (Khaeruman et al., 2024; Qurrata'ain et al., 2025). Integration with Google Sites provides flexible and collaborative access, allowing students to interact both online and offline (Khumairoh et al., 2025; Wulansari et al., 2025).

The integration of interactive e-modules supported by Google Sites in physics literacy courses plays an important role in fostering students' scientific literacy and problem-solving skills. This approach enables students to not only understand factual knowledge, but also develop scientific thinking skills through the process of interpreting phenomena, making evidence-based decisions, and solving problems systematically and rationally (Hanifah et al., 2025; Indrasari, 2025; Widya et al., 2023). Based on these considerations, the development of interactive e-modules based on Google Sites is considered relevant as a learning innovation to improve students' problem-solving skills.

Method

This study applies research and development (R&D) methods with the aim of producing valid and usable learning products. This method allows researchers to systematically design, test, and refine products according to learning needs. The product developed is an interactive e-module for literacy courses in physics learning using Google Sites. This e-module is designed to support meaningful, interactive, and accessible learning, with the integration of various media such as text, images, videos, and interactive quizzes to increase student engagement. The focus of the research is on developing teaching materials that are relevant to the needs in the field, easy to apply in lectures, and in line with the learning outcomes of the course. The research stages are carried out sequentially following the established development procedures.

This study uses the Plomp Model as a reference for development. The Plomp model has comprehensive, structured stages that can be adapted to various field situations (Plomp & Nieveen, 2013). The main advantage of this model lies in its ability to integrate theoretical foundations with empirical findings from previous research to produce valid and relevant learning products. Therefore, the Plomp model is considered appropriate for use in the development of technology-based teaching materials, such as interactive e-modules assisted by Google Sites, because it allows the process of designing, validating, and refining products to be carried out systematically and continuously. The development stages of the Plomp model are shown in Figure 1.

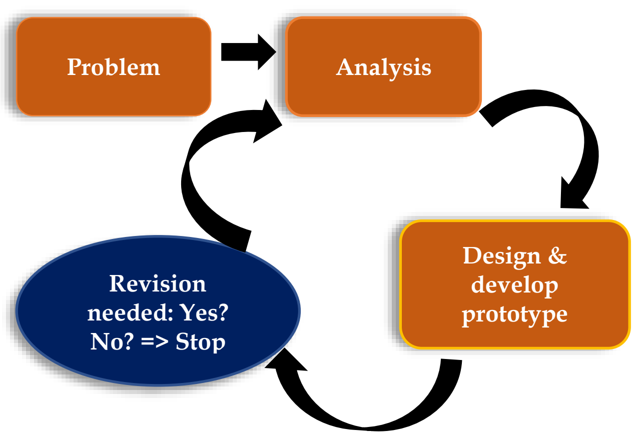

Figure 1. Stages of the Plomp model

The research procedure followed the three main stages of Plomp's model, namely preliminary research, prototype development, and evaluation. The initial stage of the research was the preliminary research stage. This stage aimed to identify and analyze the needs for developing interactive e-modules. At this stage, curriculum analysis, student characteristic analysis, learning context analysis, and analysis of previously used learning tools were conducted. This analysis is important for identifying the gap between ideal and actual conditions, particularly in relation to low problem-solving skills and the limitations of available digital teaching materials. The results of this analysis are used as the basis for designing the initial e-module using Google Sites to suit the learning needs and characteristics of the students.

The second stage is the prototype stage. At this stage, researchers design and develop an initial product in the form of an interactive e-module using Google Sites. The prototype stage includes initial design, revision, and repeated evaluation of the product until a suitable prototype is obtained. The evaluation stage focuses on testing the feasibility of teaching materials through limited trials in the classroom. Each stage is carried out sequentially to ensure that the resulting product has been thoroughly tested and meets learning needs.

This study utilized several instruments to collect data related to product development. In the initial stage, data were obtained through observation sheets, questionnaires, and document analysis to identify students' learning needs. The validity instrument used assessment sheets completed by experts to assess the suitability of the content, language, and design of the interactive e-module supported by Google Sites. Meanwhile, the practicality instrument in the form of a student response questionnaire was used to evaluate the ease of use and suitability of the e-module in learning. Each instrument was specifically designed so that the data obtained were relevant to the research objectives and product development stages.

In the preliminary stage, an analysis was conducted on the needs and context. The data obtained were then analyzed quantitatively by applying appropriate mathematical formulas to objectively assess the level of learning needs and contextual constraints. The findings from this stage form the basis for the design of interactive e-modules supported by Google Sites, which are tailored to the needs of students and the characteristics of literacy courses in physics education. The e-modules developed are in line with the demands of 21st-century learning. The calculation for the requirements analysis data is based on the following equation.

$$Value = \frac{Score}{Max\ Score} x100\% \quad (1)$$

The developed product was then validated to assess its validity level before being tested. The validation process used validity instruments that had been designed based on indicators of content, construction, and appearance suitability. The validity test was conducted by three lecturers specializing in Physics Education from Padang State University (UNP), each of whom holds a doctorate and has expertise in the field of learning media development and curriculum design. The results of the validation by the experts were used as a basis for revising and refining the product to meet the eligibility criteria before the field trial stage.

Table 1. Interpretation of Needs Analysis and Context (Widoyoko, 2016)

Criteria	Interval
>90	Very High
80-90	High
70-79	Enough
60-69	Low
<60	Very Low

In addition to validity testing, this study also conducted practicality testing. This test was used to assess several important aspects of the developed product, including the content of the e-module, the design and media of the e-module, the ease of use of the e-module, and student learning independence. The practicality test was conducted to obtain an overview of the extent to which the interactive e-module assisted by Google Sites is easy to use, interesting, and helps students learn independently. The data from the validity and practicality tests were then analyzed using Cohen's Kappa coefficient (Boslaugh & Watters, 2008). This formula is used to measure the level of agreement among assessors regarding the validity and practicality of the developed product. The calculation is based on the following equation.

$$k = \frac{\rho_o - \rho_e}{1-\rho_e} \quad (2)$$

Table 2. Interpretation of Product Validity and Practicality (Boslaugh & Watters, 2008)

Criteria	Interval
0.00-0.20	Very low
0.21-0.40	Low
0.41-0.60	Currently
0.61-0.81	Hight
0.81-1.00	Very high

Results and Discussion

Results

Preliminary research is the initial stage in product development. This research provides information about learning needs and contexts. The needs and contexts analyzed include students' problem-solving abilities, the context of teaching materials used, student analysis, and material analysis. These results form the basis for the development of interactive e-modules using Google Sites.

Results of Needs and Context Analysis

The first analysis concerns students' problem-solving abilities. Indicators of problem-solving abilities include identifying problems, planning solutions, solving problems according to plan, and evaluation (Karyawan et al., 2025; Lasumbu et al., 2024; Riyadi et al., 2020). The instrument used was an essay test. The results of the analysis of students' problem-solving abilities are shown in Table 3.

Table 3. Problem Solving Skiils Analysis Results

Problem Solving Skiils	Value	Category
Identifying problems	69.00	Low
Problem-solving planning	67.00	Low
Solving problems according to plan	68.00	Low
Evaluation	66.00	Low
Average	67.80	Low

Based on the data in Table 3, the results of students' problem-solving abilities can be explained. The value of the indicator for identifying problems is 69.00 in the low category. The problem-solving planning indicator score is 67.00, which is in the low category. The problem-solving according-to-plan indicator score is 68.00, which is in the low category. The evaluation indicator score is 66.00, which is in the low category. The average problem-solving ability score is 67.80, which is in the low category. Based on the analysis results, it can be concluded that students' problem-solving ability is still in the low category.

The second analysis relates to the analysis of the context of the teaching materials used. The analysis was conducted on four components of the teaching materials. The components analyzed included self-instructional, self-contained, adaptive, and user-friendly. This analysis formed the basis for evaluating the suitability of the teaching materials with the characteristics of 21st-century learning. The results of the analysis of the context of teaching materials are shown in Table 4.

Table 4. Results of Teaching Material Context Analysis (Prastowo, 2015)

Component	Average Value
Self-instructional	50.00
Self-contained	70.00
Adaptive	40.00
User friendly	45.00
Average	52.50

Based on Table 4, the results of the analysis of the teaching materials used can be described. The self-instructional component score of 50.00 is in the very low category. The self-contained component score of 70.00 is in the adequate category. The adaptive component score of 40.00 is in the very low category. The user-friendly component shows a value of 45.00, which is in the very low category. The average value of the analysis of electronic physics teaching materials is 52.50, which is in the very low category. The lowest indicator is found in teaching materials that cannot be applied under various conditions. Based on the analysis results, it shows that the teaching materials currently used are not in line with the required criteria for effective teaching materials.

The third analysis relates to student analysis. Student analysis data were obtained through a questionnaire distributed online via Google Forms. The analysis covers the dimensions of attitude, knowledge, and skills. The first student analysis is the attitude dimension. There are six components, namely liking group learning (GL), proposing ideas to the group to discuss in the lesson (GD), accepting friends' ideas or opinions in learning (AI), showing enthusiasm in learning (EL), reading the learning material before it is explained in class (LB), and submitting assignments given by lecturers on time (SA). The results of the student attitude analysis can be seen in Figure 2 below.

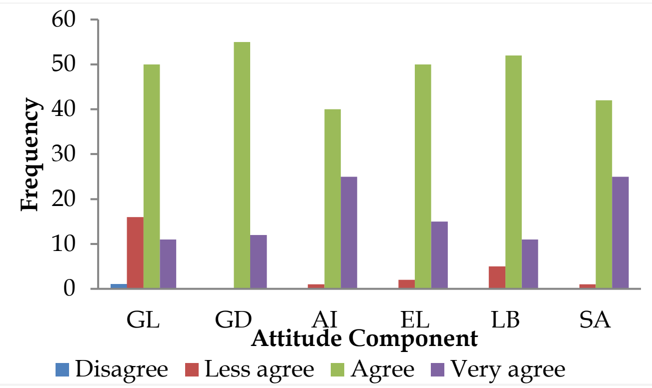

Figure 2. Results of student attitude analysis

Based on Figure 2, the results of the analysis of student attitudes can be explained. The results show that more than 75% of the sample agreed with each statement. This means that the attitudes of the students before and during the learning process were very good. The component of students proposing ideas to the group received the most votes in the agree option. This statement shows that students enjoy group learning and are active in group discussions. The majority of students showed discipline in submitting assignments on time, indicating a sense of responsibility in attending lectures. Students also showed openness in accepting their friends' opinions and enthusiasm during the learning process in class. Overall, the results of the analysis of student attitudes were in the good category.

The second student analysis is the knowledge dimension. There are ten components of knowledge. These components are learning that is relevant to everyday life (LR), learning that is found in everyday life and makes students enthusiastic about expressing their opinions (FL), learning that starts from facts makes it easier to connect it to learning (LF), conceptual learning (CL), learning using concepts will make learning simpler (UC), the use of equations in learning improves understanding of the relationship between equation variables (UR), the ability to use equations directly in learning (UE), the use of learning resources (UL), understanding sub-sections of material sequentially (UM), and the sequence of topics in learning affects understanding (TL). The results of the analysis of student knowledge can be seen in Figure 3 below.

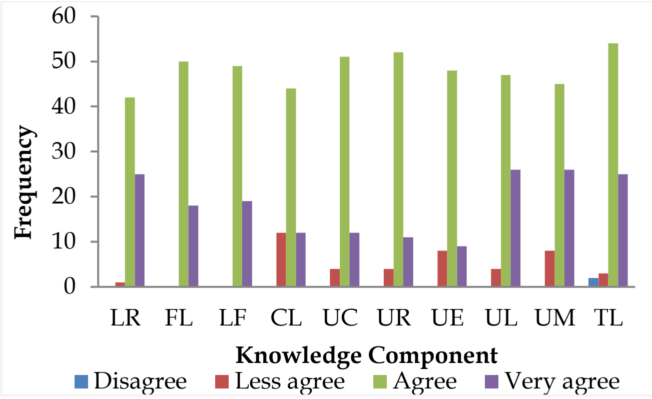

Figure 3. Results of student knowledge analysis

Based on Figure 3, the results of the analysis of students' knowledge components can be explained. The results show that approximately 50% of the sample agreed with each statement. The analysis results show that students consider the importance of the relationship between physics and everyday life. Learning that begins with real facts is considered helpful in understanding concepts and increasing enthusiasm. They also realize the importance of topic sequence in deepening their understanding of the material. Conceptual learning had the highest frequency of "disagree" responses compared to other statements. This shows that students dislike conceptual learning but prefer learning that uses equations. Overall, the results of the analysis of students' knowledge show that it is in the good category.

The third student analysis is the skill dimension. There are ten components, namely: learning abilities that require soft skills in solving real-life problems (SS), the ability to understand information presented in physics learning problems (AU), the ability to develop solution plans when given problems in physics learning (DS), the habit of double-checking procedures and solution results (PS), being able to apply solution plans in physics learning (IS), presenting group discussion results with enthusiasm (RS), preferring digital teaching materials to printed teaching materials (TM), being accustomed to using digital teaching materials in learning (UD), liking feedback in interactive teaching materials (IT), and recognizing the use of digital teaching materials using Google Sites (GS). The results of the analysis of student skills can be seen in Figure 4 below.

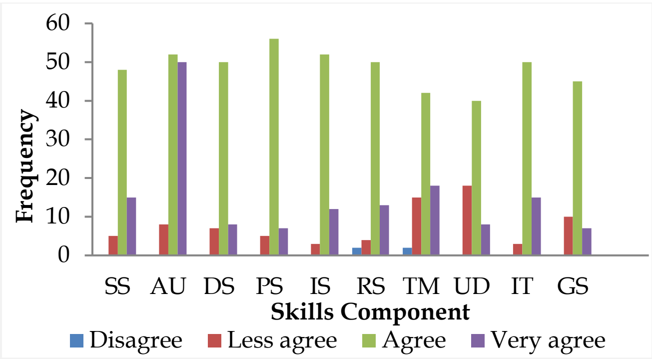

Figure 4. Results of student skill analysis

Based on Figure 4, the results of the analysis of student skills can be explained. The results show that 70% of the sample agreed with each statement. These findings indicate that students have positive skills in problem-based learning, solution planning, reflection on results, and the application of physics concepts. The level of agreement was also high regarding the use of interactive digital teaching materials, such as Google Sites. Overall, these results indicate that students' skills in physics learning are good and adaptive to digital innovation.

The fourth needs analysis relates to material analysis. This analysis aims to identify the suitability of learning content with the learning outcomes of the Literacy in Physics Learning course. This analysis was conducted to systematically examine the factual, conceptual, principled, procedural, and metacognitive aspects of various types of literacy relevant to the context of physics learning. Through this material analysis, it is hoped that an in-depth picture of the potential for integrating various types of literacy will be obtained. The results of the material analysis are shown in Table 5.

Table 5. Material Analysis Results

Aspect	Analysis Results
Material suitability	The material is in line with the learning outcomes of the course literacy in physics education
Types of literacy	Basic literacy, science, environment, digital, disaster, health, culture, and financial
Material structure	Organized based on facts, concepts, principles, procedures, and metacognitive aspects
Relevance	Every literacy contributes to the development of students' problem-solving skills

Based on Table 5, the results of the material analysis can be explained. The initial analysis of the material shows that the literacy components studied include basic literacy, science literacy, environmental literacy, digital literacy, disaster literacy, health literacy, cultural literacy, and financial literacy. Each type of literacy was analyzed based on the aspects of facts, concepts, principles, procedures, and metacognition to obtain an overview of the level of complexity of the material that can be used in literacy-based physics learning. The results of the identification show that the literacy material has a strong correlation with the development of students' problem-solving skills.

Results of the Validity Test of Interactive E-Modules Assisted by Google Sites

The research results obtained from the needs analysis stage produced a preliminary design for the e-module. After the development process was completed, the product was tested through validity and practicality stages to ensure its quality and suitability. Thus, the main findings of this study are as follows. The product produced is an interactive e-module for literacy courses in physics learning assisted by Google Sites, which is designed to improve students' problem-solving skills. The development of this e-module follows the guidelines for developing e-modules that are systematic, interactive, and in line with 21st-century learning needs. The interactive module developed with the help of Google Sites is displayed in Figure 5.

Figure 5. Homepage of e-modul interaktif

The product developed is an interactive e-module for physics literacy courses using Google Sites. This e-module is designed as a digital learning medium that combines conceptual content, interactive activities, and science literacy-based evaluation. This e-module also includes activities to facilitate problem-solving skills. The e-module was developed using Google Sites as its main platform. This e-module is easily accessible, has an interactive display, integrates multimedia (text, video, and simulations), and supports independent learning. The e-module provides features for materials, assignments, evaluation, and virtual laboratories. This interactive e-module using Google Sites can be accessed anytime and anywhere. This design can transform learning from teacher-centered to student-centered, in line with the demands of 21st-century learning.

Figure 6. Assignment and virtual lab features

The interactive e-module displays the main navigation page for assignments. The navigation includes the Practice, Quiz Time, and Assignments features, which are presented through interactive icons and buttons. This display shows that the e-module not only provides conceptual content, but also interactive learning activities that encourage student engagement and activity in problem solving. The integration of PhET Interactive Simulations is also an advantage, as it provides a realistic, safe, and easily accessible virtual experiment experience. This feature allows students to independently explore physics concepts through interactive simulations, thereby improving conceptual understanding and problem-solving skills. The use of PhET is also in line with 21st-century learning as it supports students' active involvement in the scientific investigation process. The integration of this virtual laboratory makes the e-module richer, more applicable, and relevant to modern learning needs.

After the development stage was completed, the interactive e-module supported by Google Sites was tested through an evaluation process to assess its validity and suitability. The evaluation process covered four main components, namely material substance, learning design, visual communication, and software usage aspects. The validation activity involved three expert lecturers from the Faculty of Mathematics and Natural Sciences, Padang State University. The results of the validation process are presented in Table 6.

Table 6. Results of Evaluation by Experts

Aspects	Validity Value	Criteria
Material substance	0.91	Valid
Learning design	0.90	Valid
Visual communication	0.70	Valid
Utilization of software	0.94	Valid

Based on the data listed in Table 6, the results of the validation of the interactive e-module assisted by Google Sites can be explained. The validity value of the material substance component is 0.91 within the valid criteria. The learning design component score is 0.90 within the valid criteria. The visual communication component score is 0.70 within the valid criteria. The software utilization component score is 0.94 within the valid criteria. The average score obtained from the four validity aspects is 0.86 within the valid criteria. Based on the analysis, the interactive e-module supported by Google Sites is declared valid.

Results of the Practicality of Interactive E-Modules Assisted by Google Sites

The next stage of this process is conducting practicality tests to evaluate the usability of interactive e-modules supported by Google Sites. These practicality tests were administered to students. At this stage, students used the interactive e-module supported by Google Sites in the learning process. The practicality test consists of several components, namely the content of the e-module, the design and media of the e-module, the ease of use of the e-module, and student learning independence. Initial findings from the practicality test were obtained from individual evaluations.

One-to-one practicality was conducted on three physics education students at Padang State University who took a course on literacy for physics learning. The instrument used was a practicality sheet. Practicality indicators included the content of the e-module, the design and media of the e-module, ease of use in the e-module, and student learning independence. The results of the one-to-one evaluation analysis can be seen in Table 7.

Based on the data listed in Table 7, the practicality results of the interactive e-module assisted by Google

Sites can be explained. The scores for the indicators of e-module content, e-module design and media, ease of use of the e-module, and student learning independence ranged from 0.63 to 0.78 within the practical category. The average practicality score for each criterion is 0.69 within the practical category. Based on the results of the one-to-one practicality analysis, the interactive e-module supported by Google Sites that was developed is practical for use in the learning process.

Table 7. Practical Results of Interactive E-Modules Using Google Sites in One-to-One Evaluation

Aspects	Practicality Value	Criteria
Content of the e-modul	0.78	Practical
Desing and media of the e-module	0.68	Practical
Ease of use in the e-module	0.67	Practical
Student learning independence	0.63	practical

The second practicality is small group evaluation. Small group practicality was also conducted on students of the Physics Department of Padang State University. The instrument used was also a practicality sheet. The practicality indicators were the same as those for one-to-one practicality. This instrument was given to nine students after they received learning using interactive e-modules assisted by Google Sites. The results of the small group evaluation analysis are shown in Table 8.

Table 8. Practical Results of Interactive E-Modules Using Google Sites in Small Group Evaluation

Aspects	Practicality Value	Criteria
Content of the e-modul	0.77	Practical
Desing and media of the e-module	0.74	Practical
Ease of use in the e-module	0.67	Practical
Student learning independence	0.63	practical

Based on the data listed in Table 8, the practicality results of the interactive e-module assisted by Google Sites can be explained. The scores for the indicators of e-module content, e-module design and media, ease of use of the e-module, and student learning independence ranged from 0.63 to 0.77 within the practical category. The average practicality score for each criterion is 0.70 within the practical category. Based on the results of the small group practicality analysis, the interactive e-module supported by Google Sites that was developed is practical for use in the learning process.

Discussion

The results achieved in this study are in line with the research objectives. These three results are derived from the analysis of the needs, validity, and limited practicality of interactive e-modules assisted by Google Sites. The first result achieved in this study is the analysis of the needs and context of the development of interactive e-modules assisted by Google Sites. The results of the analysis of needs and context include students' problem-solving abilities, the context of the teaching materials used, student analysis, and material analysis.

Needs and context analysis shows that students' problem-solving skills are still in the low category (Asih et al., 2022; Bahtiar et al., 2022; Erniwati et al., 2022), while the teaching materials used do not yet meet the demands of 21st-century technology integration (Akcil et al., 2021; Al-Sindi et al., 2023; Prastowo, 2015). Analysis of students reveals that they have a positive attitude and readiness towards collaborative, contextual, and problem-solving learning, thus requiring more interactive and adaptive learning media (AlAli, 2024; Guilherme & Santos, 2023). In addition, material analysis shows that the literacy content compiled is relevant to learning outcomes and supports the strengthening of problem-solving skills (Audrin & Audrin, 2022; Auliya et al., 2023; Cincera et al., 2023; Fitria, 2023; Jamaluddin et al., 2025). These findings form the basis for the development of interactive e-modules in physics literacy courses using Google Sites to improve students' problem-solving skills.

The second result of this study is the validity of interactive e-modules supported by Google Sites. The validity results show that interactive e-modules obtained high validity scores in all assessment components, namely content substance, instructional design, visual communication, and software utilization (Kemendiknas, 2010). The validation aspect also produced a Cohen's Kappa value > 0.61, which is categorized as valid (Boslaugh & Watters, 2008; Kartini et al., 2019; Khasanah et al., 2019). This high validity score is influenced by design features such as active hyperlinks, systematic navigation flow, integration of visual illustrations, and the structured presentation of literacy content in accordance with the design principles for developing digital teaching materials (Fitri et al., 2024; Linda et al., 2021; Nugraheni & Pratomo, 2025; Rahmayani & Asrizal, 2024).

The validity of the e-module is demonstrated through the validator's appreciation of the completeness and quality of interactive features that support effective learning. This e-module not only has hyperlink-based navigation and adaptive feedback, but also includes formative quizzes, structured exercises, problem-solving tasks, interactive evaluations, and interactive virtual laboratories that allow students to explore concepts independently. These features are considered to improve concept understanding, engagement, and learning independence. These findings are also supported by previous research results that quizzes and interactive evaluations increase engagement and understanding (Büchele et al., 2025; Durgungoz & Durgungoz, 2025; Ole & Gallos, 2023), problem-solving tasks enhance higher-order thinking skills (Apipah et al., 2024; Uliyandari et al., 2021), and interactive virtual laboratories strengthen science literacy and digital experimentation experiences (Kashaka, 2024; Shambare & Simuja, 2024). Thus, interactive e-modules based on Google Sites can be used to optimize the learning process.

The third result of this study is the practicality of interactive e-modules based on Google Sites. The results of data analysis from the practicality instrument show that interactive e-modules based on Google Sites have a high level of practicality in terms of usefulness, content feasibility, interface design, ease of use, and support for independent learning (Alfa & Asrizal, 2024; Asrizal et al., 2025; Rahmatsyah & Dwiningsih, 2021; Virijai & Asrizal, 2023). This practicality is mainly due to ease of access and responsive display across various devices. The integration of videos, images, and interactive activities in one platform also makes it easier for students to follow the learning process continuously (Haspen & Syafriani, 2020; Nafeli et al., 2024; Nazifah & Asrizal, 2022; Rahmatsyah & Dwiningsih, 2021).

The practicality test results show that interactive e-modules based on Google Sites are very easy for students to use. This platform provides clear navigation, cross-device access, and stable media integration, thereby facilitating the independent learning process optimally (Alqurni & Faisal, 2023; Kitt-lewis et al., 2024; Wicaksono et al., 2023). In addition to ease of access, students also assessed that interactive features such as exercises, quizzes, assignments, and direct feedback helped them manage their learning pace, understand the material gradually, and increase their motivation and engagement in learning. These findings are in line with previous research, which shows that the interactivity and flexibility of digital platforms play an important role in increasing the effectiveness of independent learning and student engagement in online learning environments (Faza & Lestari, 2025; Pinheiro et al., 2021; Xu et al., 2023). Thus, the interactive e-modules developed meet the practical aspects well, making them suitable for use in the learning process.

Based on the analysis, the interactive e-modules developed for the literacy course in physics learning assisted by Google Sites were found to be necessary, valid, and practical. These findings indicate that the e-modules can effectively support the learning process. Previous studies also emphasize that valid and practical technology-based teaching materials are feasible for instructional use (Alfa & Asrizal, 2024; Fitri et al., 2024; Irdawati et al., 2023; Novit et al., 2023). Furthermore, interactive e-modules have been shown to enhance 21st-century skills and problem-solving abilities (Andang et al., 2025; Kusumaningsih et al., 2025; Oktavia et al., 2025; Pairunan et al., 2025; Rahmatullah et al., 2025). Thus, the Google Sites–assisted interactive e-modules developed in this study have the potential to facilitate students' problem-solving skills in physics learning.

Conclusion

Based on data from the research and development of interactive e-modules in literacy courses in physics learning using Google Sites, three main results can be concluded. First, the needs analysis shows low problem-solving skills and limitations in the teaching material context, thus requiring the development of more innovative e-modules. The analysis results also show that the characteristics of the students are in the good category, thus supporting the implementation of these teaching materials. Second, the validity of the interactive e-module developed reached 0.86, indicating that the e-module is valid. Third, the average practicality score was 0.70 in the practical category. These results indicate that the interactive e-module developed is necessary, valid, and practical. These findings confirm that the e-module has met the quality criteria for development, making it suitable for use in learning and ready to proceed to the effectiveness testing stage to assess its potential in improving students' problem-solving skills.

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Author Contributions

D.S.S., contributed to managing research activities, from conceptualizing research ideas (product development and data collection) to writing and editing articles. F.N., contributed to the editing of the article. R.O., contributed to data analysis and article editing. H.Y., contributed to data collection and article editing. A., contributed to article editing. All authors have read and approved the published manuscript.

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Conflicts of Interest

The authors have declared that no conflict of interest exists in the conduct of research and the subsequent publication of scientific results.

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