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DEVELOPMENT OF AN INTERACTIVE E-MODULE BASED ON PROBLEM-BASED LEARNING TO IMPROVE PROBLEM-SOLVING SKILLS IN CLASS VII INFORMATICS.

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Abstrak
Salah satu keterampilan penting dalam pembelajaran informatika adalah kemampuan pemecahan masalah. Namun, pembelajaran informatika biasanya berfokus pada guru dan penggunaan bahan ajar konvensional yang kurang interaktif. Akibatnya, keterlibatan siswa dan pemahaman materi yang abstrak belum optimal. Tujuan penelitian ini adalah untuk membuat dan menguji media E-Modul Interaktif berbasis Problem-Based Learning yang akan membantu siswa dalam memecahkan masalah. Studi ini menggunakan model ADDIE, yang terdiri dari tahapan analisis, desain, pengembangan, implementasi, dan evaluasi. Subjek penelitian adalah siswa SMP Negeri 2 Singaraja. Hasil penelitian menunjukkan bahwa E-Modul Interaktif dapat membantu berbagai tahapan sintaks pembelajaran berbasis masalah, seperti orientasi masalah melalui penyajian kasus kontekstual, pengorganisasian belajar melalui panduan aktivitas penyelidikan, penyelidikan mandiri dengan dukungan materi dan simulasi interaktif, pengembangan dan penyajian hasil melalui latihan berbasis masalah, dan evaluasi melalui umpan balik otomatis.

Kata Kunci: E-Modul Interaktif; Problem-Based Learning; Kemampuan Pemecahan Masalah; Informatika

Abstract
One of the important skills in computer science education is problem-solving ability. However, computer science education usually focuses on the teacher and the use of conventional teaching materials that are less interactive. As a result, student engagement and understanding of abstract material are not yet optimal. The aim of this research is to create and test an Interactive E-Module based on Problem-Based Learning that will help students in solving problems. This study uses the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. This study was conducted at SMP Negeri 2 Singaraja,. The research results show that the Interactive E-Module can assist various stages of the problem-based learning syntax, such as problem orientation thru the presentation of contextual cases, learning organization through investigation activity guides, independent investigation with material support and interactive simulations, development and presentation of results thru problem-based exercises, and evaluation thru automatic feedback.

Keyword*: Interactive E-Module, Problem-Based Learning, Problem-Solving Skills, Informatics*

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INTRODUCTION

The rapid advancement of educational technology in the digital era has significantly transformed the learning process as part of broader efforts to improve the quality of education. Technology is no longer viewed merely as a supporting tool, but has evolved into an essential component in creating learning experiences that are effective, flexible, and aligned with the needs of students in the twenty-first century (Mesra et al., 2023). To achieve this transformation, educational systems are required to integrate technology into all aspects of learning so that students not only become technology users, but also develop critical thinking, creativity, and individual problem-solving skills.

The transformation of twenty-first century education also requires students to coexist with digital technology, the internet, computers, and smartphones in their daily lives (Agustini et al., 2022) (Mamolo, 2022). As a result, the use of Information and Communication Technology (ICT) has become one of the most important components of modern learning (Parwati et al., 2023). Nevertheless, various empirical findings indicate that the utilization of technology in school learning remains far from optimal. Learning materials in many educational institutions are still dominated by printed books and static PDF files, which are considered less capable of encouraging active student engagement and critical thinking skills (Alfan Afifi Kurniawan et al., 2023).

Similar problems were identified in Informatics learning at SMP Negeri 2 Singaraja. Initial observations revealed that the learning process still tended to rely on conventional approaches through lecture-based methods (Azizah, 2021). This condition resulted in limited student engagement, particularly when students were required to understand abstract concepts. In addition, the implementation of the independent curriculum continues to face various challenges in practice (Nugraha, 2022). This finding is consistent with the study conducted by (Lestari et al., 2026), which showed that conventional learning approaches tend to make students passive and unable to improve their scientific attitudes and learning outcomes. Therefore, a more interactive and student-centered learning approach is needed.

The implementation of the latest curriculum has encouraged the adoption of a deep learning approach in Informatics learning. This approach aims to create meaningful and conscious learning experiences. However, its implementation still encounters several challenges, particularly because teachers do not yet fully understand the approach and appropriate interactive teaching materials are still limited. In Informatics learning, problem-solving ability is considered one of the most essential competencies that students must master. This ability includes understanding problems, designing strategies, implementing solutions, and evaluating results (Ivane & Dewi, 2022). Consequently, learning models that encourage students to actively engage in solving real-world problems are highly needed. Since each student has a unique approach to solving problems, Informatics learning plays a significant role in developing twenty-first century problem-solving skills (Assulamy Hafif et al., 2024).

Teachers are able to present authentic problems within Informatics learning so that students can understand the relevance of the subject matter to their daily lives. One learning model that can facilitate such a process is problem-based learning (Josapat Eleaser et al., 2023). As part of the cooperative learning model category, problem-based learning requires students to solve problems either collaboratively or individually. Empirically, this model has been proven to improve students' problem-solving abilities, particularly in Informatics learning. This is because problem-based learning encourages students to identify problems, analyze data, and formulate solutions independently (Salsabilah Muslim et al., 2024).

The continuous development of technology has also supported the emergence of interactive e-modules as a potential solution for implementing problem-based learning. Interactive e-modules

allow the integration of various multimedia elements, such as images, audio, text, and video, with the objective of improving students' problem-solving abilities. This concept is supported by the Cognitive Theory of Multimedia Learning, which states that presenting information simultaneously through verbal and visual channels can improve learning effectiveness (Mayer, 2014). This argument is further strengthened by the findings of (Djahara et al., 2026), which demonstrated that the development of problem-based interactive learning media can enhance contextual learning and critical thinking during decision-making processes. In addition, problem-based scenarios within interactive simulations allow students to become directly involved in the learning process. Students not only acquire knowledge, but are also confronted with real-world situations that require them to analyze conditions, make decisions, and determine solutions. Such an approach is considered effective in improving higher-order thinking skills as well as deepening students' understanding of learning materials.

Previous literature has shown that problem-based learning e-modules are effective in improving student learning outcomes and engagement during the learning process (Melyastiti et al., 2023). Furthermore, the development of e-modules using the ADDIE development model demonstrated that the aspects of content, design, and media achieved a very high level of validity (Dari & Sudatha, 2022). However, previous studies have not extensively developed interactive e-modules integrated with problem-based learning models, particularly in Informatics subjects, nor have they widely utilized the Articulate Storyline platform in the development process. Moreover, the implementation of deep learning approaches has not yet been carried out comprehensively (Khusnah et al., 2020).

Based on these conditions, this study developed a problem-based interactive e-module that integrates a deep learning approach in Informatics learning. The development of this e-module aims to provide learning experiences that are enjoyable, engaging, meaningful, contextual, and interactive, while simultaneously improving students' problem-solving abilities.

METHOD

The development process in this study employed the Research and Development (R&D) method using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages (Branch, 2010). The development process involved several stages and procedures, which are illustrated in Figure 1.

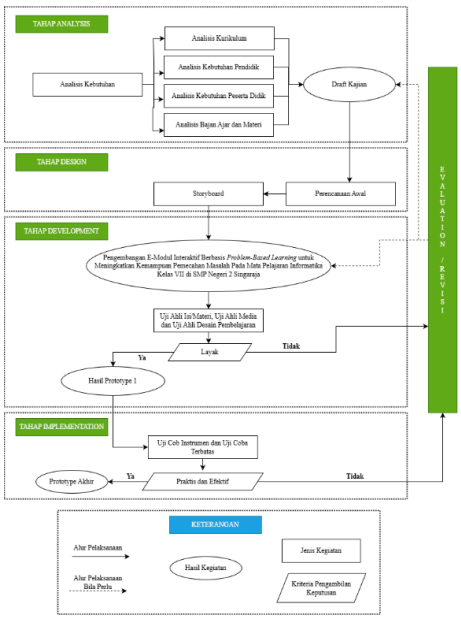

Figure 1. ADDIE Development Procedure

The first stage aimed to identify the need for developing learning media to improve students' problem-solving abilities, particularly in the Informatics subject. The results showed that the learning process still relied heavily on conventional teaching materials, indicating that interactive media were needed to enhance students' problem-solving skills.

The second stage, namely the design stage, aimed to formulate solutions to the problems identified during the analysis stage through the development of an effective and efficient learning system that aligned with field requirements. At this stage, concept maps, material frameworks, and the interface design of the e-module were developed, including the integration of multimedia elements, navigation systems, and learning flow. In addition, practicality questionnaires, expert validation sheets, and problem-solving ability tests were also designed.

The third stage was the development stage. During this stage, the e-module was developed using the Articulate Storyline application by integrating interactive simulations, text, images, and engaging videos. The resulting product was subsequently validated by content experts, media experts, and design experts to evaluate the feasibility of the developed product. The validation results were then used as the basis for revisions before proceeding to the trial stage.

Furthermore, a practicality test was conducted using the System Usability Scale (SUS) questionnaire. The SUS assessment consisted of 10 questions covering several aspects, including Learnability, Simplicity and Complexity of the e-module system, Usability, Consistency and Integration, Confidence, and Support Need. After the data were collected and analyzed, the analysis results were converted into a media practicality scale.

The fourth stage, namely implementation, aimed to apply the problem-based learning interactive e-book product that had previously been validated by content, media, and design experts, so that the developed product was ready to be implemented in teaching and learning activities. The effectiveness level of the product was measured by comparing students' pre-test and post-test results based on Informatics problem-solving ability tests using learning mastery values through the T-test and N-Gain analysis to determine the achievement of learning objectives.

The fifth stage was evaluation, which aimed to provide systematic feedback to the developers so that the interactive e-module development process could meet the predetermined needs and expectations. Evaluation was carried out comprehensively at every stage of development to ensure that all implemented processes were able to achieve the intended learning objectives and provide an effective and optimal learning experience.

RESULT

The validation data of the developed interactive e-module learning media based on the problem-based learning model, particularly for the Informatics subject, were obtained from the assessments conducted by content experts as well as media and design experts, which aimed to evaluate the feasibility of the product before implementation. In the implementation of this product, the assessment results are presented in detail in Table 1.

Table 1. Expert Review Results

Subject	Result		
	Expert 1	Expert 2	Criteria
Content	90%	96%	Very Good
Media	100%	100%	Very Good
Design	100%	100%	Very Good

Based on the response questionnaire presented in Table 1, the validation results of the successfully developed interactive e-module obtained a "very good" criterion across all assessment aspects. The content expert validation process obtained percentages of 90% and 96%, while the validation conducted by media and design experts each obtained a percentage of 100%. These results indicate that the developed e-module has fulfilled the feasibility criteria and is suitable for use in the Informatics learning process.

Table 2. Results of Teacher Practicality Review

Subject	Hasil		
	Total Score	Percent	Criteria
Teacher 1	49	98%	Very Practical
Teacher 2	50	100%	Very Practical
Teacher 3	50	100%	Very Practical

The results presented in Tables 2 and 3 indicate that the interactive e-module achieved a "very good" criterion based on both teacher and student assessments. The practicality test conducted by teachers showed percentages ranging from 98% to 100%, while the student practicality test obtained a percentage of 92.44%. These findings demonstrate that the developed e-module is easy to use, not confusing, and capable of supporting the learning process effectively.

Table 3. Results of Student Practicality Review

Subject	Result		
	Total Score	Percent	Criteria
Student (=9)	416	92.44%	Very Practical

Furthermore, an effectiveness test was conducted to determine the influence of the e-module on students' problem-solving abilities by comparing the pre-test and post-test results. The average pre-test score was 56.86, while the post-test score increased to 80.80. These results indicate that learning supported by the e-module improved students' performance. In addition, the N-Gain calculation showed a moderate value of 0.55, indicating that the e-module effectively assisted students in improving their problem-solving skills.

To strengthen these findings, an effect size analysis was conducted using the Hedges'd formula. The Hedges value of 2.24 was categorized as a Large Effect. This result indicates that the use of the Problem-Based Learning interactive e-module had a very strong and significant impact on improving students' problem-solving abilities. Based on the literature review, the Hedges method was selected because it is a corrected form of Cohen's d that provides a less biased effect estimation, particularly for small to medium sample sizes (Khairunnisa et al., 2022).

The high effect size value was influenced by several factors, including the substantial difference between the average pre-test and post-test scores as well as the relatively small standard deviation, which indicates that the improvement in students' abilities occurred consistently. In addition, the difference between the very large effect size and the moderate N-Gain category does not represent a contradiction, but rather reflects differences in measurement concepts. Effect size measures the strength of the mean difference relative to data variation, meaning that a large score increase combined with relatively low variation produces a high effect size value. Meanwhile, N-Gain measures the effectiveness of improvement relative to the maximum possible score increase (Meltzer, 2002).

This study successfully developed a problem-based learning interactive e-module to improve seventh-grade students' Informatics problem-solving abilities. The interactive e-module can be accessed by students through smartphones, notebooks, PCs, or laptops via the following website: https://media-interaktif.github.io/Petualangan-Digital-Kelas-VII/.

Several supporting applications were utilized in the development of this interactive e-module product. The applications included Canva for creating designs, YouTube for uploading learning videos, and Canva Site as an interactive simulation platform for the Computational Thinking material.

Figure 1. Learning Activity Page Display

The structure of the interactive e-module consists of a cover page, an opening page, and activity pages that include three learning activities. These activities cover the introduction to computational thinking, the importance of organizing data, and basic data processing. The following section presents the display of the developed interactive e-module product.

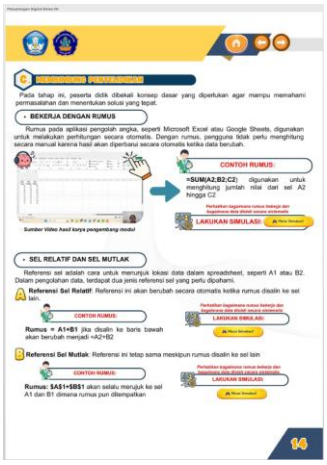

Figure 2. Activity Page Display for Learning Activity 3

The learning activities within this interactive e-module were designed based on the syntax of the problem-based learning model, including problem orientation, organizing learners, guiding investigations, developing and presenting results, and evaluation. Figure 2 illustrates an example of the third learning activity, in which students are presented with a problem-based video and are then able to conduct simulations to understand how the formula works.

DISCUSSION

The purpose of this study was to develop a problem-based learning interactive e-module for seventh-grade Informatics subjects and to examine its validity, practicality, and effectiveness in improving students' problem-solving abilities. The results showed that the developed e-module was not only feasible for use, but also capable of providing positive impacts on both the learning process and

learning outcomes. This discussion is organized into four main aspects, namely product design and development, validity, practicality, and effectiveness of the e-module.

From the product design perspective, the development of this e-module integrated the problem-based learning model into an interactive adventure-based digital learning design. The results of the needs analysis indicated that Informatics learning was still dominated by textbooks and worksheets, which reflected the use of conventional teaching materials that were less capable of facilitating active student engagement. This condition is consistent with previous findings showing that conventional learning approaches tend to be ineffective in developing higher-order thinking skills (Ardianti et al., 2022). Therefore, the development of an interactive e-module was proposed as a relevant solution to address these learning needs.

The e-module design process followed the syntax of problem-based learning, including stages of problem orientation, student organization, investigation, solution development, and evaluation. The presentation of problems through videos and "digital adventure" narratives was proven to enhance both learning processes and student motivation because students learned through contexts closely related to their daily lives. This discussion is supported by Cindy E. Hmelo-Silver (2004) and John R. Savery (2006), who stated that problem-based learning is capable of encouraging students to develop critical thinking and problem-solving skills through authentic experiences. In addition, the mission-based design provided a non-linear learning experience that allowed students to explore materials in a more flexible and meaningful manner (Komang Sudarma et al., 2021).

In the implementation process, the syntax of Problem-Based Learning was systematically integrated through several stages. In the first stage, problem orientation was realized through videos and "digital adventure mission" narratives presented at the beginning of each lesson. The problems presented in the videos were designed to be closely related to students' daily lives, thereby fostering curiosity, increasing intrinsic motivation, and activating prior knowledge. The presentation of problems as "missions" functioned not only as triggers, but also as frameworks directing the entire learning activity. The second stage, namely organizing learners, was implemented in the e-module through the presentation of learning objectives and clear activity instructions. At this stage, students were guided to understand the scope of the problem and independently plan solution strategies.

The third stage involved either independent or guided investigation, facilitated through material exploration, interactive simulations, and student activities aimed at analyzing information. Students were not limited to reading materials, but were also encouraged to experiment with problem-solving strategies through the available features. This process reflects the primary characteristics of the Problem-Based Learning model (Khairunnisa et al., 2025). The fourth stage, namely developing and presenting solutions, was implemented through problem-based exercises and the preparation of structured answers or solutions. Students were encouraged to formulate solutions based on the data and concepts they had learned. The final stage, evaluation, was facilitated through reflection activities at the end of the lesson. Reflection represents an important syntax within PBL to strengthen metacognitive awareness and encourage students to apply their knowledge to different situations.

From the perspective of deep learning, the design of this e-module integrated three main dimensions, namely mindful, meaningful, and joyful learning. The mindful learning aspect was reflected through the presentation of explicit learning objectives, guiding questions that directed thinking processes, and progress bar features that strengthened students' awareness of learning achievements (Mulyani et al., 2025). The meaningful learning aspect was implemented through the presentation of real-life problems closely connected to students' daily experiences, enabling them to relate Informatics concepts to real-world situations (Wijaya et al., 2025). Meanwhile, the joyful learning aspect was integrated through an interface design featuring digital adventure themes, visual

illustrations, mission-based menus, exercises, and interactive simulations that enhanced intrinsic motivation (Ni Made Ayu Dyah Chrishanty et al., 2025).

From the perspective of learning theories, the development of this e-module was also supported by several theoretical foundations. Constructivist theory was reflected in the student-centered learning design, where students actively constructed knowledge through exploration and investigation (Andi Asrafiani Arafah et al., 2023). Cognitive theory was reflected in the systematic organization of materials and the use of scaffolding through guiding questions and feedback (Ardianti et al., 2022). Meanwhile, elaboration theory was applied in organizing materials from simple to complex concepts (Reigeluth, 2021), thereby helping to reduce students' cognitive load. The integration of behaviorist theory was also evident in the provision of immediate feedback as reinforcement (Abidin, 2022), while connectivist theory supported the utilization of technology as a digital learning medium.

The validity test results showed that the developed e-module was categorized as very good. Content validity obtained a high percentage, indicating that the materials were aligned with learning outcomes, presentation systematics, and appropriate conceptual depth. This finding demonstrates consistency with the principles of instructional design, which emphasize the integration between objectives, materials, and evaluation (Sudarma et al., 2024). Furthermore, the aspects of feedback and motivation that obtained maximum scores indicated that the e-module was capable of providing engaging learning experiences and supporting active student involvement.

In addition, media and design validity also demonstrated very good results, particularly in terms of navigation, interactivity, and media design. This finding indicates that multimedia learning principles proposed by Richard E. Mayer (2014), such as coherence, signaling, segmenting, and modality, had been fulfilled by the e-module. It has been proven that presenting materials through combinations of interactive simulations, videos, texts, and audio can improve students' understanding of abstract concepts. Therefore, the e-module was not only relevant in terms of content, but also in terms of presentation and user experience.

The practicality test results also showed that the e-module was highly practical from both teacher and student perspectives. Teachers stated that the e-module was easy to use, did not require complicated technical assistance, and had a clear and systematic structure. Meanwhile, students showed positive responses toward the appearance of the e-module, its ease of use, and its attractiveness. This indicates that the e-module fulfilled the usability criteria measured by the System Usability Scale (SUS), developed by John Brooke (1986), which is frequently used to evaluate digital learning systems. This high level of practicality indicates that the developed product can be effectively implemented in real learning contexts.

This improvement cannot be separated from the pedagogical design of the e-module, which integrated problem-based learning, interactive multimedia, and digital scaffolding. The problem-based learning model served as the primary framework encouraging students to think systematically and reflectively (Warpala et al., 2024). Meanwhile, the use of multimedia helped visualize abstract concepts, thereby facilitating students' understanding in accordance with Mayer's theory (2014). Scaffolding features, such as gradual exercises and immediate feedback, also assisted students in correcting mistakes and independently constructing knowledge.

Previous studies have shown that the use of problem-based e-modules can improve students' problem-solving abilities (Juniardi, 2023). In addition, it has been proven that the use of technology in learning can increase students' motivation and engagement in lessons (Fatimah et al., 2023).

Therefore, through the use of Articulate Storyline as the development platform, digital adventure design, and deep learning approaches, this study strengthens previous findings.

Nevertheless, this study also has several limitations. The process of developing a digital adventure-based e-module required a relatively long period of time, particularly during the scenario design and interactive simulation stages (Sugianto et al., 2021). In addition, feature limitations within the Articulate Storyline platform also became challenges in developing learning evaluations. However, these limitations did not reduce the quality of the resulting product, but instead became evaluation materials for future development.

Overall, the findings of this study indicate that the developed problem-based interactive e-module fulfilled the criteria of validity, practicality, and effectiveness. The module helped students improve their problem-solving abilities while also providing more meaningful, engaging, and contextual learning experiences. Therefore, this e-module can be utilized as an alternative teaching material in Informatics learning.

CONCLUSION

This study aimed to develop a problem-based interactive e-module for seventh-grade Informatics subjects. The results showed that the developed module fulfilled the criteria of being highly valid in terms of content, media, and instructional design, highly practical based on teacher and student responses, and highly effective in improving students' problem-solving abilities. These findings indicate that the problem-based interactive e-module was capable of enhancing students' problem-solving skills and successfully supported the objectives of the study through the integration of problem-based learning models, digital scaffolding, and interactive multimedia. Nevertheless, the development of this e-module still encountered limitations related to technical aspects and development time. Therefore, future studies are recommended to develop more complex evaluation features, expand implementation across different materials and educational levels, and integrate more adaptive technologies to improve the quality and sustainability of digital-based learning.

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