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Designing an Interactive Digital Magazine E-Module to Foster Mathematical Problem solving Skills through Differentiated Instruction

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ABSTRACT

A major challenge in junior high school mathematics learning, particularly in the topic of Systems of Linear Equations in Two Variables (SLETV), lies in students' low problem solving ability, stemming from instructional materials that fail to accommodate diverse learning styles. This study aims to develop and evaluate an interactive digital magazine based e-module that integrates Problem Based Learning (PBL) and supports differentiated instruction to enhance students' mathematical problem solving skills. A development research design was employed using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Participants included subject-matter experts, media experts, mathematics teachers, and eighth-grade students at SMPN 7 Jambi City. Instruments consisted of validation questionnaires, practicality questionnaires, and problem solving tests. The research procedure covered expert validation, individual testing, small-group testing, and large-group testing. Quantitative data were analyzed using statistical software to assess validity, practicality, and effectiveness. Results show that the e-module is highly valid, practical, and effective in improving students' problem solving ability, as indicated by the N-Gain scores. This interactive e-module offers a promising alternative instructional medium that supports differentiated instruction and contributes to the development of 21st-century skills.

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Introduction

Systems of Linear Equations in Two Variables (SLETV) is one of the essential topics in the junior high school mathematics curriculum that plays an important role in developing mathematical modeling skills and logical reasoning. However, various studies show that SLETV is one of the most challenging topics for students. Students often experience difficulties in understanding the concept of variables, constructing mathematical models from contextual

problems, and solving systems of equations through substitution, elimination, or graphical methods (Yusnita & Pramudya, 2021; Lestari & Mahmudah, 2023). This problem has a direct impact on the low level of students' mathematical problem solving skills, which is a key competence of the 21st century.

A preliminary study conducted in class VIII K of SMPN 7 Jambi City confirmed this problem. Based on the results of diagnostic tests and interviews with teachers, most students answered SLETV questions directly without systematic procedures, and many were unable to connect the questions with the appropriate mathematical models. In addition, the results of observations showed that learning was carried out conventionally and did not make use of teaching materials that support visual or interactive learning styles. Teachers only used textbooks from the Merdeka Curriculum without developing other supplementary teaching materials. This also exacerbated the low motivation and participation of students in learning SLETV.

In response to these conditions, it is necessary to develop innovative teaching materials that can attract students' attention and facilitate the process of mathematical thinking. One alternative solution offered is the development of an interactive digital magazine based e-module. This format combines the strengths of visual design and multimedia to improve students' interest and understanding. Previous studies (Munawaroh et al., 2021; Saparini et al., 2023) showed that e-modules presented in magazine style can increase learning activity and provide an enjoyable learning experience. Compared to conventional text-based e-modules, digital magazines offer more flexible content delivery, with features such as colorful illustrations, animations, and interactive quizzes.

The innovation of this e-module does not stop at the visual format but is also integrated with the Problem-Based Learning (PBL) approach. PBL is a learning strategy that places contextual problems as a starting point to encourage students to think critically and creatively. By adopting PBL in the structure of the e-module, students are trained to identify problems, design solutions, and evaluate the results reflectively. Research by Ananda & Fauziah (2022) and Jayanti et al. (2024) emphasized that the combination of technology-based teaching materials and the PBL approach is effective in improving problem solving skills and engaging students actively.

Based on this background, this study aims to develop an interactive digital magazine based e-module based on PBL that supports differentiated instruction in the SLETV topic. The novelty of this research lies in the design of the e-module that integrates digital magazine format, the PBL approach, and differentiated instruction principles simultaneously using the Heyzine Flipbook platform. This study is expected to contribute to the development of innovative learning media and serve as a reference for teachers in implementing adaptive, engaging, and effective classroom instruction.

Method

Type of Research

This study is classified as development research, or Research and Development (R&D), which aims to produce an interactive digital magazine based e-module that is feasible for use in mathematics learning. The development process followed the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was selected because it provides systematic yet flexible procedures for designing technology-based learning programs. Moreover, it has proven effective and is widely applied in research on instructional media development (Branch, 2009 in Bajri et al., 2024; Awalia, 2023). Each stage

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of the ADDIE model offers structured guidance for designing, constructing, and evaluating learning media step by step, with an emphasis on achieving optimal learning outcomes.

Population and Samples

This study involved four groups of subjects: content experts, media experts, teachers, and students. The content and media experts were lecturers from the Mathematics Education Department, Universitas Jambi, who validated the content and design of the e-module. The teacher involved was a Grade VIII mathematics teacher at SMPN 7 Jambi City, responsible for evaluating the e-module's practicality. Meanwhile, students from class VIII K at the same school participated in three trial stages: an individual trial (1 student), a small-group trial (9 students), and a large-group trial (28 students). Subjects were selected purposively, taking into account the suitability of their characteristics with the research objectives.

Instruments

This study employed two main instruments: questionnaires and a mathematical problem solving test. The validation questionnaire for experts assessed the content and design validity of the e-module. It covered two aspects: (1) material, including curriculum alignment, conceptual accuracy, and clarity of presentation, and (2) media/design, including visual aesthetics, interactivity, and navigation. Example items included: "The material presented aligns with the basic competencies of SLETV" and "The presentation of mathematical concepts in the e-module is easy to understand." Responses were rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The practicality questionnaire, administered to teachers and students, evaluated the ease of use, attractiveness, and practicality of the e-module. Example items were: "The e-module design is attractive and motivates me to learn" and "Navigation between pages in the module is easy to use." In addition, a mathematical problem solving test consisting of four open-ended questions was developed based on Polya's indicators: (1) understanding the problem, (2) devising a strategy, (3) carrying out the solution, and (4) checking the result. One example item was: "*The price of 2 pencils and 3 books is Rp45,000, while the price of 4 pencils and 2 books is Rp60,000. Determine the price of a pencil and a book, and explain the solution process.*"

Procedures

The product development process in this study followed the five stages of the ADDIE model. In the first stage, Analysis, the need for instructional materials at SMPN 7 Jambi City was identified. Observations indicated that teachers relied solely on textbooks without digital media support. At the same time, students demonstrated low motivation to learn. The curriculum, basic competencies, and learner characteristics were also analyzed as the foundation for product design. In the second stage, Design, learning objectives were formulated, content and storyboards for the digital magazine based e-module were prepared, and the user interface along with multimedia elements was designed using the Heyzine Flipbook platform. The e-module design integrated a Problem-Based Learning (PBL) approach to foster students' critical thinking skills. In the third stage, Development, the product was created based on the design and validated by content and media experts. Feedback from the validation process was used to revise the e-module. The fourth stage, Implementation, involved three levels of trials: individual, small group, and large group. At this stage, questionnaires and tests were administered to assess the practicality and effectiveness of the e-module. Finally, in the Evaluation stage, both formative and summative evaluations were conducted to determine the

success of the developed product and to provide a basis for further refinement (Branch, 2009; Awalia, 2023).

Analysis

Data analysis in this study was divided into three aspects: validity, practicality, and effectiveness. Validity analysis, expert evaluations were analyzed by calculating the mean score for each aspect and converting it into percentages. The interpretation categories were: 85–100% = very valid, 70–84% = valid, 55–69% = fairly valid, and < 55% = less valid. Practicality analysis, questionnaires from teachers and students were averaged and converted into percentages, with interpretation categories identical to those used for validity. Effectiveness analysis was measured using students' pretest and posttest mathematical problem solving scores. The analysis employed the Normalized Gain (N-Gain) formula:

$$\text{N} - \text{Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

N-Gain values were classified into three levels: high (≥ 70%), moderate (40–69%), and low (≤ 39%) (Navila, 2021). Furthermore, the effectiveness of the e-module was interpreted based on the categories proposed by Sriwahyuni and Maryati (2022): not effective (< 40%), less effective (40–55%), moderately effective (56–75%), and effective (> 76%). In addition to quantitative analysis, qualitative data derived from expert, teacher, and student comments were analyzed descriptively to enrich and complement the quantitative results.

Results

Research findings are presented in accordance with the stages of the ADDIE development model, namely Analysis, Design, Development, Implementation, and Evaluation. The resulting product is an e-module in the form of an interactive digital magazine designed to support differentiated instruction on the topic of Systems of Linear Equations in Two Variables (SLETV). In the Analysis stage, a needs analysis was conducted through observation, interviews, and document review at SMPN 7 Jambi City. The results indicated that students experienced difficulties in solving SLETV problems due to a lack of understanding of systematic problem solving steps. Moreover, the learning process had not yet utilized diverse digital resources, as teachers relied solely on the *Kurikulum Merdeka* textbook. Students also reported boredom with conventional classroom activities, highlighting the need for innovative and engaging instructional media. In the Design stage, the learning objectives flow (ATP) and learning outcomes were prepared based on the *Kurikulum Merdeka*. The e-module structure was then designed to include a cover, table of contents, basic competencies, concept map, learning materials, practice exercises, instructional videos, interactive quizzes, and a glossary. This stage also involved the preparation of a storyboard and the mapping of content into the Heyzine Flipbook digital platform.

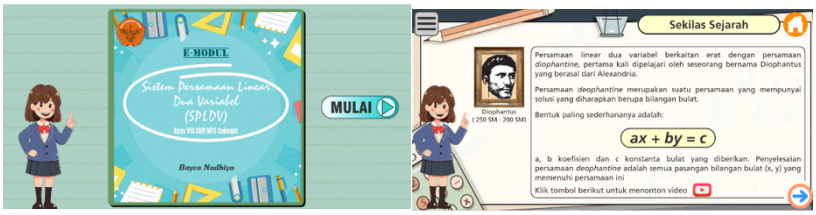

Figure 1. Module Display

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Table 1. Learning Outcomes and Objectives

Learning Outcomes	Learning Objectives
Students are able to solve linear equations and inequalities in two variables as well as systems of linear equations in two variables using various methods for problem solving.	1. Explain the concept of SLETV and model real-life problems into SLETV. 2. Determine the solution of SLETV using the elimination method. 3. Determine the solution of SLETV using the substitution method. 4. Determine the solution of SLETV using the graphical method. 5. Solve real-life problems related to SLETV.

Following the completion of the initial product, validation was conducted by subject-matter experts and media experts to evaluate the quality of the e-module. Validation by subject-matter experts assessed content relevance, language use, and depth of material, yielding a score of 96.25% and categorized as highly valid. Meanwhile, validation by media experts examined appearance, interactivity, and navigation, producing a score of 91.11%, also classified as highly valid. Data were analyzed using SPSS software to process questionnaire scores based on a Likert scale. The results demonstrate that the content, presentation, language, and visualization of the module align with the principles of effective and engaging instructional material development. As no major revisions were recommended, the module was deemed appropriate for further trial implementation.

At the implementation stage, three types of trials were conducted as illustrated in Figure 2. The individual trial was conducted with one eighth-grade mathematics teacher. The practicality questionnaire yielded a score of 92.59%, categorized as highly practical. Based on the teacher's assessment, a total score of 125 was obtained out of a maximum of 135, with an average of 4.62. These results indicate that the e-module met the practicality criteria in the highly practical category and was considered feasible for use in research with only minor revisions. The small-group trial involved nine eighth-grade students. The practicality questionnaire yielded a score of 85.27%, also categorized as highly practical. A total score of 307 was obtained out of a maximum of 360, with an average of 4.26. Thus, the e-module was confirmed to meet the practicality criteria in the highly practical category. The field trial involved 28 eighth-grade students who used the e-module over two learning sessions. Pre-test and post-test were administered to measure improvements in problem solving ability. Students' responses to the practicality questionnaire yielded a total score of 900 out of a maximum of 1,120, corresponding to 80.35%, and categorized as highly effective. Accordingly, the e-module was deemed to meet the effectiveness criteria and is suitable for classroom implementation.

Figure 2. Results of the Individual Trial Questionnaire

Product evaluation focused on the effectiveness of the e-module, assessed through students' mathematical problem solving test results in the field trial. The results indicated that 22 students (78.6%) achieved very high improvement, while 6 students (21.4%) demonstrated high improvement. The average N-Gain score was 0.86 (86%), which is classified as high. Specifically, 22 students were categorized as having very high improvement, and 6 students were categorized as having high improvement.

Table 2. Mean N-Gain Scores

Measure	N	Minimum	Maximum	Mean	Std. Deviation	Category
N-Gain Score	28	0.63	1.00	0.86	0.12	High
N-Gain Percent (%)	28	62.50	100.00	86.42	11.72	High
Pretest Score	28	20.00	40.00	28.75	–	Low
Posttest Score	28	70.00	100.00	89.64	–	Very High

As shown in Table 2, the average pretest score was 28.75 (low), while the average posttest score increased to 89.64, classified as very high. These findings demonstrate that the interactive digital magazine based e-module had a positive effect on improving students' mathematical problem solving skills. The integration of Problem-Based Learning (PBL) within the module further supported students in understanding problem contexts, designing solutions, and evaluating their thinking processes independently. Overall, the findings confirm that the developed e-module met the criteria of high validity, high practicality, and effectiveness for application in differentiated instruction. Its engaging design, multimedia features, and problem-based approach make it a feasible interactive teaching resource that supports the implementation of the *Kurikulum Merdeka*.

Discussion

The development of the interactive digital magazine based e-module demonstrated positive results in terms of validity, practicality, and effectiveness. The high validity scores for both content and media indicate that the e-module met the quality standards for technology-based instructional materials. This finding is in line with Rahayu et al. (2022), who emphasized that digital learning media designed with readability, attractive visualization, and curriculum alignment play a crucial role in facilitating the understanding of abstract mathematical concepts, including SLETV. From the practicality perspective, both teachers and students responded positively. The e-module was considered easy to use, visually engaging, and relevant to the needs of Grade VIII learning. This supports Munawaroh et al. (2021), who found that digital magazine–style materials enhance student engagement by reducing monotony from text-dominated formats. The magazine design used in this study also enabled students to navigate the content more flexibly according to their own thought processes.

The effectiveness of the e-module was evident in the significant improvement of students' mathematical problem solving skills after its implementation. This improvement can be explained by three main factors: first, the integration of Problem-Based Learning (PBL) engaged students with real-world problems that stimulated critical thinking; second, the visual and multimedia features strengthened students' conceptual understanding of SLETV, which is often perceived as abstract; and third, the combination of differentiated instruction and interactive content allowed students to learn according to their pace and style. These results are consistent with Ananda & Fauziah (2022), who reported that combining PBL and digital media creates an active and constructive learning environment.

The novelty of this research lies in its simultaneous integration of three elements: the interactive digital magazine format, PBL principles, and differentiated instruction. Unlike most

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previous studies that focused only on text-based e-modules, this study highlights how visual design, narrative flow, and multimedia features can be merged into a cohesive learning tool. In this sense, the study contributes new insights in terms of media format, pedagogical approach, and application to mathematics learning on SLETV. Furthermore, the findings extend prior studies. For instance, Saparini et al. (2023) showed that interactive modules could improve learning outcomes by up to 90%, but did not examine integration with PBL or the Merdeka Curriculum. This study strengthens the evidence that systematically designed interactive digital magazine based e-modules hold strong potential as alternative instructional media in the digital era, particularly within the context of Merdeka Curriculum implementation.

Conclusion

This study concludes that the development of an interactive digital magazine based e-module for teaching Systems of Linear Equations in Two Variables (SLETV) proved valid, practical, and effective. By integrating Problem-Based Learning (PBL) and differentiated instruction, the module successfully addressed students' difficulties in understanding concepts and systematically solving SLETV problems. The module was rated highly valid by content and media experts, highly practical by teachers and students, and effective in improving students' mathematical problem solving skills. It also provided an engaging and adaptive learning experience through its magazine-style visuals and problem-based content. The novelty of this study lies in the simultaneous integration of three elements (interactive digital magazine format, PBL approach, and differentiated instruction) which have rarely been combined in instructional media for SLETV. Despite these promising results, the study has limitations. The trial was limited to a single class, and non-cognitive aspects such as motivation and interest were not examined in depth. In addition, the data analysis was primarily descriptive, even though statistical software was employed. Future studies should expand the population and sample, evaluate broader learning aspects, and explore interactive features such as gamification or augmented reality. These improvements would further strengthen the role of digital e-modules as adaptive, engaging, and transformative learning tools.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

B.N. contributed to research design, instrument development, conceptualization, data collection, data analysis, and writing of the results and discussion. W.S. contributed to revising the manuscript and aligning the overall content of the study. N. contributed to refining the discussion and approving the final version of the manuscript. The overall percentage of

contributions to conceptualization, preparation, and revision of this article is as follows: B.N.: 50%, W.S.: 25%, and N.: 25%.

Data Availability Statement

The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [B.N.], upon reasonable request.

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