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Development of E-Modules Based on Problem-Based Learning to Increase the Creativity of Grade 2 Elementary School Students in Mathematics Subjects

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Abstract: The urgency of this study stems from the lack of interactive and contextual learning media in early-grade mathematics, which limits students' creativity. This research aimed to develop an electronic module based on Problem-Based Learning to enhance the creative thinking skills of second-grade elementary students, particularly in learning simple fractions. Employing a research and development approach using the Plomp model, the study consisted of three phases: preliminary research, prototyping, and assessment. Data were collected through expert validation, questionnaires, and student performance assessments, then analyzed using descriptive quantitative techniques. The results showed that the developed e-module was valid based on expert judgment (average validity score > 0.90), practical according to teacher and student responses (average practicality > 85%), and effective in improving creativity, as evidenced by increased scores in fluency, flexibility, and originality (mean score 80.44%). The findings indicate that integrating Problem-Based Learning into digital modules can significantly support the development of students' creativity and engagement in mathematics. This innovation offers practical implications for curriculum-aligned learning media and supports the development of 21st-century skills. Further research is recommended to explore broader applications and incorporate adaptive digital features.

Keywords: Creativity; E-module; Elementary school; Mathematics education; Problem-Based Learning

Introduction

A child's cognitive abilities and character are laid the groundwork for their future success in school through primary education. Contextual, exploratory, and meaningful learning is essential for students in the concrete operational phase of development. Mathematics is one of the fundamental subjects at this level. It is not only concerned with numerical concepts but also functions as a medium to foster logical, systematic, and creative thinking. However, field data reveal that the implementation of mathematics instruction in lower elementary grades still encounters various significant challenges (Herzegovina et al., 2023; Melyastiti et al., 2023).

The researcher interviewed and observed second graders at SDN 14 Pincuran VII Pasia in order to form this preliminary conclusion, several critical problems were identified. First, students tend to be passive and show limited initiative in solving mathematical problems. When given problem-solving tasks, most students simply imitate the examples provided by the teacher without attempting their own strategies. Second, instruction is still dominated by lecture-based methods,

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and the textbook is used as the sole learning resource. Learning materials are delivered unidirectionally and emphasize memorization, without involving activities that stimulate students' creative thinking. Third, the learning process has yet to integrate interactive digital media, despite students' familiarity with technology. As a result, learning becomes monotonous, unengaging, and does not motivate students to actively participate (Adiansha & Nurgufrini, 2025; Zuliani et al., 2023).

Septia Damanik et al. (2025) found that a lack of contextual and interactive learning media is to blame for elementary students' low levels of creative thinking, which is in line with these difficulties. Teachers generally rely on printed instructional materials that offer little opportunity for students to independently explore ideas. Moreover, the instructional approach does not encourage students to confront and collaboratively solve real-life problems. Similar findings were also reported by Rani and Rani & Alfiandra (2025), who noted that conventional learning materials contribute to low levels of creativity and learning motivation.

To address these issues, we need to develop innovative educational resources that encourage critical thinking and creativity. One option is to use PBL-based electronic modules (e-modules). Problem-based learning (PBL) is an educational model that places students at the centre of the learning process by asking them to analyse real-world problems, form hypotheses about those problems, and then propose solutions (Manurung & Marini, 2023). When used with an electronic module (e-module), this technique not only encourages creativity but also makes learning engaging and relevant to new technology.

An electronic module (e-module) is a digital teaching tool that organises and interactively presents learning materials, allowing students to learn independently. In 2025, Septia Damanik and colleagues discovered that interactive e-modules can help students think more logically and become more engaged in their studies. Rani and Alfiandra (2025) discovered similar results, indicating that project-based electronic modules (e-modules) increased the creativity of middle school students. Herzegovina et al. (2023) discovered that PBL based e-modules help students better understand thematic learning and are suitable for use in elementary school.

When students use the problem-based learning approach to create an electronic module (e-module), they do more than just passively absorb knowledge. In contrast, students learn how to think creatively, critically, and analytically in real-world contexts. (Fitri and Syafiqoh, 2020). While many studies have looked at how e-modules can be built using problem-based learning, most of these studies have focused on upper elementary or junior secondary levels of education. Two studies, one by Adiansha and Nurgufrini (2025) and the other by Manurung and Marini (2023), have demonstrated that PBL effectively increases creativity. But it is still not used very often in the lower elementary grades, particularly in the second grade.

Herzegovina et al. (2023) also discovered that incorporating problem-based learning into electronic modules (e-modules) within thematic learning enhanced students' comprehension of the subject matter, although this methodology has predominantly been applied at the fifth-grade level. Moreover, research Melyastiti et al. (2023) and Septia Damanik et al. (2025) underscores that an effectively designed electronic module (e-module) must take into account the attributes of learners and integrate the comprehensive syntax of problem-based learning to promote creative and contextual thinking.

To prepare students for the 21st century, teaching methods need to change so that they can learn HOTS, especially critical thinking, creativity, collaboration, and communication (Handayani & Koeswanti, 2021). Among these, creativity is an important skill that should be developed from a young age, especially in elementary school. So, it's very important to use teaching methods that give students real-world problems to solve and encourage them to think of new ideas.

PBL is one of the best ways to teach that helps kids be creative. This model emphasizes the importance of students actively engaging in contextual problem-solving and promotes innovative and adaptable thinking (Kusmiati, 2022; Ramadanti et al., 2021). PBL can be a great way to make learning spaces that are flexible, meaningful, and focused on the student when technology like electronic modules (e-modules) is used to help.

Information and communication technologies, like electronic modules (e-modules) that use flipbooks or multimedia, have been shown to make teaching better and get students more involved. It is believed that e-modules that combine text, images, audio, and video are better at teaching hard material and making people think and feel (Endaryati et al., n.d.; Kumalasani & Eilmelda, 2022). Electronic modules (e-modules) can be utilized not only for instruction but also for exploration, contemplation, and knowledge construction within the problem-based learning framework.

This study's goal is to create e-modules based on PBL that will meet both students' needs for meaningful math learning and teachers' needs for new teaching tools that will make students more engaged, creative, and independent from an early age.

This research aims to develop a valid, functional, and efficacious e-module grounded in PBL to enhance the creativity of Grade II elementary school students in

mathematics. This study focuses on specific dimensions of creativity, namely fluency, flexibility, and originality in mathematical problem-solving and thought processes.

Method

This study is a research and development (R&D) initiative designed to create an e-module utilizing PBL to augment the mathematical creativity of second-grade elementary students. The development process follows the Plomp model, which includes three main phases: preliminary research, prototyping, and assessment. This model was selected because of its systematic structure and its emphasis on iterative product improvement through expert validation and field trials.

The preliminary research phase involved several analytical steps to identify the conditions and needs of the learning environment. Needs analysis was conducted through classroom observations and teacher interviews at SDN 14 Pincuran VII Pasia. The findings revealed that the mathematics learning process lacked interactive media and did not stimulate student creativity. Student analysis was also conducted, focusing on their developmental characteristics. As second-grade students are in the concrete operational stage, they require learning experiences that are contextual, visual, and activity-based. Curriculum analysis referred to the *Kurikulum Merdeka*, ensuring alignment between the module and the core competencies, particularly in the topic of simple fractions. Concept analysis was carried out to determine essential learning materials, with a focus on real-life problem contexts and the use of visual representations to support student understanding.

In the prototyping phase, the e-module includes components such as an introduction, learning objectives, instructional content, problem scenarios, multimedia elements, practice questions, and assessments. After development, the initial prototype was evaluated by three expert validators: a media expert, a content expert, and a language expert. The validation instrument was a Likert-scale questionnaire designed to assess content relevance, media quality, linguistic clarity, and instructional feasibility. The validation results were analyzed using Aiken's V formula (Azwars,1997):

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

Information:
V : Validity Score
S : $\sum s\ (s = r - lo)$
lo : The lowest validity rating score
r : The number given by an appraiser
c : The highest validity rating score
n: Number of items

The value of **V** obtained is then interpreted into a validity classification as shown in Table 1.

Table 1. *Validation Criteria* (Azwar, 1997)

Achievement Level	Category
$\geq$ 0,6	Valid
$<$ 0.6	Invalid

Practicality analysis was carried out after all questionnaires were completed.. The responses obtained from the questionnaires were summed and analyzed using the formula proposed by Hermawan (2019), as follows:

$$P = \frac{R}{SM} \times 100\% \quad (2)$$

Information:
P = Practicality Value
R = Score Obtained
SM = Maximum Score

We measured how well the e-module worked by seeing how creative students were when they solved math problems over three learning sessions. Students did problem-based learning tasks that were part of the module during each session. We used observation sheets and student worksheets to rate their work based on three creativity indicators: fluency, flexibility, and originality. The following formula was used to figure out each student's creativity score:

$$S = \frac{B}{C} \times 100\% \quad (3)$$

where S is the creativity score in percent, B is the score you got, and C is the highest score you could get. Descriptive evaluations of creativity were conducted during the three meetings, and the module was deemed effective if students exhibited consistent or escalating levels of creativity based on the predefined indicators.

The Plomp development model guided this methodical process, which made sure that the final instructional product met curriculum standards, met the needs of learners, was valid according to expert judgment, was easy to implement, and was effective in improving mathematical creativity through problem-based learning.

Result and Discussion

In order to make sure that the development of a Problem-Based Learning (PBL)-based electronic module

on simple fractions for second-grade elementary students goes smoothly and meets the goals, it needs to be planned and organized. The Plomp development model was used to create this e-module. Each stage includes certain development processes that are designed to meet the needs of the research and the type of learning environment.

Preliminary Research Findings

This initial research aimed to ascertain the essential requirements and factors for creating an e-module on basic fractions for Grade II elementary school students. The analysis included four key components:

Needs Analysis

Observations and interviews revealed that mathematics instruction has adopted a student-centered approach, yet students' active engagement remains limited. Teachers primarily use traditional methods and printed modules that are monotonous and visually unappealing. Many students rely on peers or the teacher rather than engaging independently. Existing learning materials lack adequate visual support, making it difficult for students to grasp fraction concepts such as one-half or one-fourth. Both teachers and students expressed interest in using electronic modules, particularly those that are interactive, colorful, and easy to understand.

Learner Analysis

Student responses indicate a preference for group learning and visually engaging modules. Most students do not regularly bring printed modules to class and are not motivated by the current materials. They prefer modules that are colorful (especially green), feature the Tahoma font, include enjoyable story problems, and provide step-by-step guidance. Observations show that students' creativity and understanding in solving math problems remain limited, especially in dealing with word problems involving fractions.

Curriculum Analysis

The development of the e-module aligns with the *Merdeka Curriculum* (Indonesian National Curriculum), particularly the *Phase A Learning Outcomes* for Grade II mathematics. Students are expected to understand fractions as parts of a whole through concrete and symbolic representations (e.g., ½, ⅓, ¼). The module will support the principles of *Merdeka Belajar* (Freedom to Learn) and *Profil Pelajar Pancasila* (Pancasila Student Profile) by facilitating differentiated, contextual, and student-driven learning experiences.

Concept Analysis

The instructional content focuses on simple fractions, presented progressively: one-half, one-third, and one-fourth. The conceptual structure of the e-module is designed to address the lack of effective visual materials and to support numeracy skills through contextual and interactive activities. The goal of this development is to connect abstract math concepts with the developmental stages and learning needs of students.

Results of the Prototyping Phase

At this point, the design and development of the e-module were based on what was learned during the first research phase. The PBL based e-module was carefully made and improved to fit the students' needs and the curriculum. The design process focused on making the content relevant to students' lives, making learning more enjoyable, and making it easy for all students to access. This way, the content helps students understand ideas and motivates them to participate in the learning process.

Use the Canva app to make an e-module that is based on PBL:

Create an electronic module cover page (e-module)

On the cover page, you can see the e-module's year of creation, the author's name, and the institution's name. Topic: "Basic Fractions with a PBL Approach." The design is intriguing and complements the subject matter. For a positive first impression of the subject, it features fraction images, such as a slice of pizza or cake.

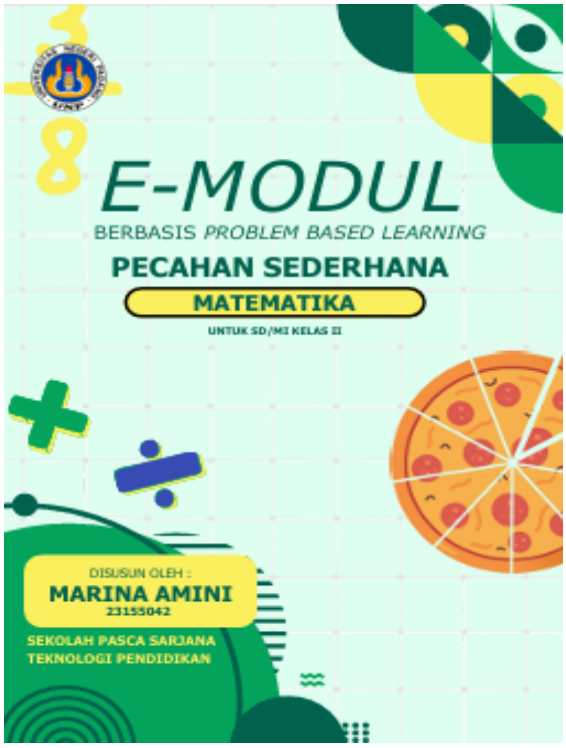

Figure 1. Cover page

E-Module Profile

The e-module profile provides a brief overview of the goals and materials. In this module, Problem-Based Learning (PBL) is used to teach students about basic fractions by solving real-world problems. The module's goal is to help students achieve meaningful and useful learning outcomes through an interactive and critical-thinking-based approach to learning.

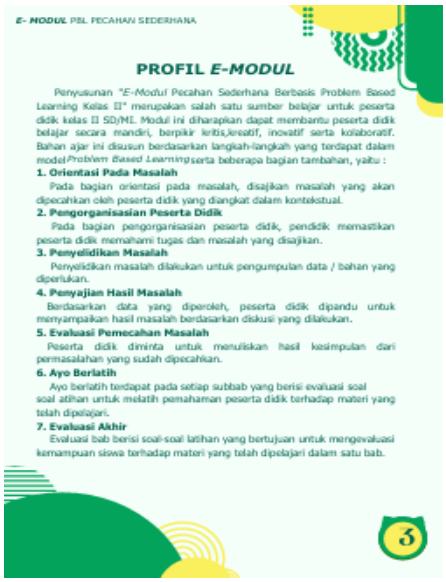

Figure 2. Display of *E-Module Profile*

Table of Contents

The table of contents outlines the structure of the module systematically, allowing users to navigate easily to specific sections. Each part, from instructions for use to the bibliography, is clearly listed with corresponding page numbers to ensure efficient access to all content.

Figure 3. Table of Contents Display

Instructions for use

This section provides an explanation of the symbols used throughout the e-module to assist users in navigating and understanding the content effectively. The symbols are designed to enhance the user experience by offering visual cues for different activities and instructions

Figure 4. Display of Instructions for Use

Learning Instructions

Learning instructions in electronic modules (e-modules) contain information in the form of directions for learning in electronic modules (e-modules) for both educators and students so that they are more focused, systematic and optimal in their use.

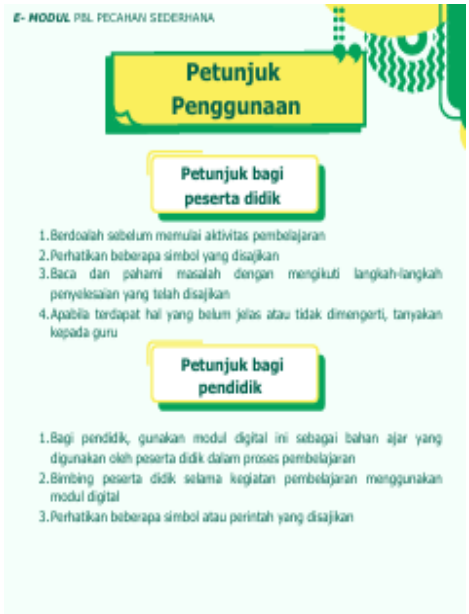

Figure 5. Display of Learning Instructions

Learning Outcomes

Learning outcomes contain learning objectives and attitudinal competencies that students are expected to achieve in the learning process. The display of learning outcomes is as follows:

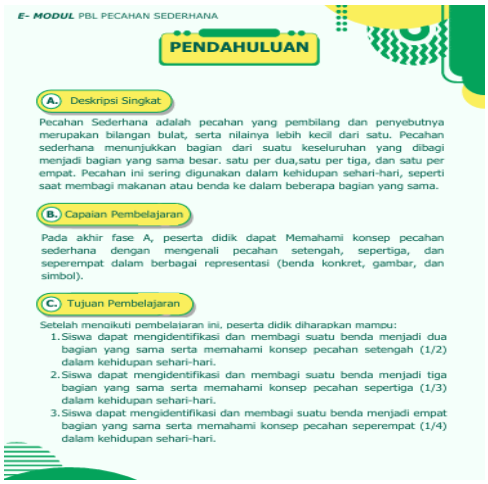

Figure 6. Display of Learning Achievements

Learning Activities in the Learning Process

Learning activities are designed to support the PBL approach, engaging students in identifying and understanding real-world problems, participating in group discussions, conducting independent investigations, and solving exercises related to fractions. These activities are interactive and structured to foster active student participation.

Figure 7. Display of material in learning activities

Bibliography

The bibliography lists the textbook references used to develop this module. The content is based on mathematics textbooks relevant to the topic of basic fractions, ensuring that the material is accurate, reliable, and aligned with the curriculum.

Figure 8. Library View

Author Profile Page

The author profile page includes a brief biography of the module's author, comprising the author's name, student identification number (NIM), current study program, and address. This section recognizes the author's contribution and provides an introduction for the users of the module.

Figure 9. Author Profile Display

Validity test

1) Media Validity

Postgraduate lecturers from universities in Padang State who focus on media were part of a validity test for media experts. Here, the researcher presents the finished media to the media experts, who then offer feedback and recommendations. Results from media experts. The results are shown in Table 2.

Table 2. Media Validator Assessment Results

Assessed Aspect	Validity Score	Category
Completeness of Media Components	0.96	Valid
Content Appropriateness	0.95	Valid
Interface	0.91	Valid
Interactivity	1.00	Valid
Technology	1.00	Valid
Average Module Validity Score	0.96	Valid

2) Validation of material experts

The material validity stage was carried out by one subject matter expert, namely a lecturer in Primary School Teacher Education at Universitas Negeri Padang, through the administration of an evaluation questionnaire. The assessment covered three main aspects: content feasibility, presentation feasibility, and instructional steps. The results of the material validator's assessment are presented in Table 3 below:

Table 3. Material Validator Assessment Results

Aspect Assessed	Validity Score	Category
Content Appropriateness	0.94	Valid
Presentation Appropriateness	0.93	Valid
Instructional Procedure Clarity	1.00	Valid
Average Module Validity Score	0.95	Valid

3) Language validity

The language validity stage was conducted by a linguistics expert, namely a lecturer from the Faculty of Languages and Arts at Universitas Negeri Padang, through the administration of an evaluation questionnaire. The assessment encompassed three aspects: conformity to linguistic rules, contextual appropriateness, and suitability for learners. The results of the language validator's assessment are presented in Table 4.

Table 4. Language validity Result

Aspect Assessed	Validity Score	Category
Conformity to Linguistic Rules	0.88	Valid
Contextual Appropriateness	1.00	Valid
Suitability for Learners	1.00	Valid
Average Module Validity Score	0.96	Valid

Practicality test

1) Results of the One-to-One Practicality Evaluation

The results of the practicality test through the one-to-one evaluation indicate that the developed media falls into the "Highly Practical" category across all assessed components. The components of readability and clarity of content, attractiveness, and time allocation suitability each achieved an indicator attainment percentage of 85%, while the component of usability and ease of use scored the highest at 89%. Overall, the average percentage of indicator attainment reached 86%, indicating that the media is highly user-friendly, engaging, and appropriately aligned with the time allocation and individual learner needs.

2) Results of the Small Group Practicality Evaluation

The small group evaluation's practicality test shows that the media that was made is "Highly Practical" in all of the parts that were tested. Readability, content clarity, usability, and ease of use all received 86% as indicators that they were met. A perfect score of 89% went to the section concerning its aesthetic appeal, while 85% went to the section detailing its processing time. Achieving the indicators was 87% on average. In other words, the media is great for group projects because it is practical, engaging, and simple to use.

3) Results of the Practicality Evaluation Based on Educator Responses

The practicality test results show that all of the components tested by teachers ranked the media created as "Highly Practical". The content was very simple to read and understand, earning a 94%. Usability and ease of use received an 86% rating. The time allocation factor received a 90% rating, while the appeal factor received the highest score of 95%. The average percentage of indicator attainment was 91%, indicating that teachers believe the media is very useful, interesting, easy to use, and fits well with the time limits for lessons.

4) Results of the Practicality Evaluation Based on Learner Responses in the Large Group

The results of the practicality test, which were given to a large group of students, show that the media created is rated "Highly Practical" in all of the areas examined. The content was rated at 89% for readability and clarity, and 92% for usability and ease of use. The media appeal received the highest score of 94%, followed by the suitability of time allocation (86%). These findings show that the media is extremely effective, simple to use, and engaging, with an overall average score of 90%. This makes it an excellent choice for use in large group learning environments.

Effectiveness test

To assess the students' creative abilities, a performance evaluation form was created using creativity indicators. These signs include creativity (the ability to think continuously), adaptability (the ability to consider alternative points of view), originality (the ability to generate new ideas), and elaboration. The goal of this assessment is to evaluate students' creative thinking skills as they work through the Problem-Based Learning E-module for Simple Fractions in a Grade II elementary school (SD/MI) setting. Figure 10 shows the results of tests that evaluated the pupils' creative abilities.

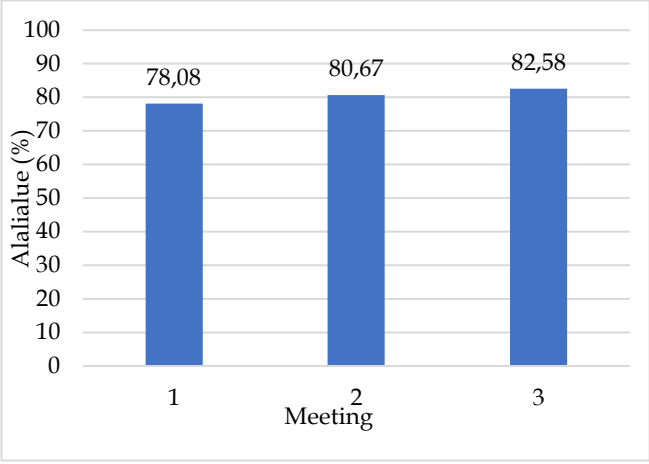

Figure 10. Results of Students' Creativity Assessment

Figure 10 shows that the average creativity scores of students went up a lot after they used the E-module. This shows that the E-module's teaching style helps students become more creative. The average score for creativity was 80.44%, which is a great score. Students were very good at coming up with new ideas, looking at problems from different points of view, and finding new ways to solve them.

The results show that the PBL E-module really does help students be more creative. The success is because of the problem-based learning parts that make you think about things, come up with new ideas, and solve problems on your own or with others. The approach aligns with constructivist theory, emphasizing that students must actively engage in knowledge construction through direct experience.

The E-module also helps make math education better in primary schools, especially by helping kids learn 21st-century skills like being creative and solving problems. So, it could be used more widely as a new way to learn that fits with what students need to learn.

The findings of this study show that the development of a PBL e-module successfully meets the criteria of being valid, practical, and efficient in enhancing the creativity of second-grade elementary students in mathematics. Expert assessments in content, media, and language confirmed that the e-module met curricular standards, was pedagogically appropriate, and cognitively appropriate for young learners during the concrete operational stage. These findings back up the findings of Septia Damanik et al. (2025) and Manurung & Marini (2023), who argued that educational media should be tailored to early-grade students' developmental characteristics in order to effectively foster higher-order thinking. The e-module had good content and construct validity because it used real-world scenarios, multimedia elements, and math problems in context.

The e-module was well received by both educators and students due to its practicality. Educators praised its ease of use and immediate implementation. It was also thought to be useful for assigning students organised learning tasks. The e-module piqued students' interest and engagement due to its interactive design and assignments based on real-life situations. These findings are consistent with those of Putri et al. (2025), who discovered that in elementary school settings, both teachers and students found e-modules based on the Creative Problem Solving (CPS) model interesting and useful.

Students improved their creative thinking skills significantly, particularly in terms of fluency, flexibility, and originality. This supports Zhan et al.'s (2024) meta-analysis, which found that teaching students how to solve problems improves their creativity, particularly in elementary school settings. Using PBL in the e-module encouraged students to engage in all aspects of creative thinking, including problem solving, idea generation, and solution generation. The systematic application of PBL syntax, including problem orientation, data collection, analysis, ideation, and reflection, was critical in enhancing students' ability to generate innovative and diverse ideas in response to contextual mathematical challenges.

The study found some problems, even though the results were good. Some of these are not having enough access to digital infrastructure, not having enough training for teachers on how to use technology in the classroom, and not having enough time to carry out the plan. The intervention was successful because the e-module focused on the learner, was relevant to real-life situations, and used visual and interactive elements.

The study's limitations encompass a small sample size, the absence of a control group, and a concentration on a single educational institution. These limitations diminish the applicability of the findings. The research should be broadened to encompass various educational settings and extended implementation durations, and subsequent studies should utilise more stringent

experimental methods, including randomised controlled trials. It might be a good idea to look into how artificial intelligence or adaptive learning could be used in the e-module to make it more personalised and have a longer-lasting effect.

Conclusion

The results of this study show that the e-module for second-grade maths, which is based on Problem-Based Learning (PBL), is valid, useful, and effective at encouraging student creativity. Expert evaluations in content, media, and language validated the material, indicating its alignment with the curriculum and the cognitive capacities of young learners. Teachers and students liked the module and said it was useful, clear, attractive, easy to use, and good for the classroom. The module's implementation significantly enhanced students' creative thinking skills, especially regarding fluency, flexibility, and originality, as demonstrated by their performance throughout the learning process.

These findings show that the incorporation of e-modules based on PBL should be more thoroughly integrated into early elementary mathematics education to promote contextual, active, and student-centered learning. Subsequent research ought to broaden its parameters by incorporating a wider array of educational contexts, utilizing experimental methodologies with control groups, and integrating adaptive digital elements to augment the personalization and efficacy of learning experiences.

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Author Contributions

Contributing authors include Nofri Hendri, M.Pd., as the media validator; Dr. Yenni Hayati, S.S., M.Hum., as the language validator; and Dr. Melva Zainil, M.Pd., as the material validator. Prof. Dr. Zelhendri Zen, M.Pd., Ph.D., served as the primary supervisor who provided comprehensive academic guidance throughout the research process. The authors also acknowledge the support of their parents, close friends, and colleagues who contributed encouragement and moral support during the completion of this study.

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Conflicts of Interest

The authors declare no conflict of interest

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