Vol. 9, No.1, 2026, pp. 16-23
DOI: https://doi.org/10.32698/02234

Contents lists available at Journal Global Econedu

Journal of Educational and Learning Studies
ISSN: 2655-2760 (Print) ISSN: 2655-2779 (Electronic)

Journal homepage: http://jurnal.globaleconedu.org/index.php/jels

Development of a problem-based learning interactive quiz for fifth-grade mathematics

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Article Info

Article history:

Received Jan 13th, 2026
Revised Feb 21st, 2026
Accepted Mar 21st, 2026

Keyword:

Problem based learning,
Interactive quiz,
Mathematics learning,
Fractions and decimals

ABSTRACT

This study aimed to develop and evaluate the validity and practicality of a Problem Based Learning (PBL)-based interactive quiz for teaching fractions and decimals in elementary school mathematics. This research employed a Research and Development (R&D) approach using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation stages. Data were collected through observations, interviews, expert validation sheets, and practicality questionnaires. The product was validated by media and material experts, while practicality was assessed through teacher responses. The needs analysis indicated that students experienced difficulties in understanding fractions and decimals and required more interactive learning media. The developed product was a web-based interactive quiz integrating contextual problem-solving activities. Media validation obtained a mean score of 3.14 (valid), material validation achieved 3.73 (very valid), and teacher practicality reached 3.86 (very good). The developed PBL-based interactive quiz is valid and practical for supporting mathematics learning on fractions and decimals at the elementary school level.

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Introduction

Mathematics is a fundamental subject in elementary education because it develops logical reasoning, critical thinking, problem-solving, and decision-making skills needed in everyday life (Bacalso et al., 2025; Marin & Movahed, 2025). In the twenty-first century, students are expected not only to perform calculations but also to apply mathematical concepts in solving real-world problems (Ahmad & Junaini, 2022; Vinutha et al., 2025). However, many elementary students still experience difficulties in achieving meaningful mathematical understanding, indicating the need for learning approaches that encourage active participation and higher-order thinking skills.

Fractions and decimals are important mathematical topics because they form the basis for learning percentages, ratios, proportions, and algebra. Nevertheless, students often struggle to understand the relationships among these concepts, especially when solving contextual problems (Pusceddu et al., 2026; Wendt et al., 2025). Many learners rely on memorizing procedures rather than understanding concepts, leading to misconceptions and low achievement. Therefore, effective instructional strategies are needed to strengthen students' conceptual understanding of fractions and decimals.

These learning difficulties are often associated with teacher-centered instructional practices that emphasize explanation and routine exercises (Astafieva et al., 2024; Naik et al., 2022). Observations also revealed that although schools possess technological facilities, their use in mathematics learning remains limited. Existing media such as PowerPoint, videos, Quizizz, and Wordwall are mainly used for content delivery and practice rather than promoting critical thinking and problem-solving. As a result, student participation and engagement in mathematics learning tend to remain low.

Advances in educational technology provide opportunities to improve mathematics learning through interactive digital media. Features such as visual representations, animations, feedback, and interactive navigation can help students understand abstract concepts more effectively (Rzyankina et al., 2024; Saputri et al., 2025). However, many digital learning products focus primarily on engagement and content presentation, while offering limited opportunities for authentic problem-solving. Consequently, digital media should be integrated with appropriate pedagogical approaches to create meaningful learning experiences.

Problem Based Learning (PBL) is a student-centered approach that promotes conceptual understanding, critical thinking, collaboration, and problem-solving through authentic tasks (Bifulco & Kerrigan, 2025; Jain et al., 2025). Previous studies have shown that both interactive learning media and PBL can improve student engagement and learning outcomes (Cheon et al., 2025; Glasnović Gracin & Trupčević, 2025). However, most studies have examined these approaches separately, and research focusing on fractions and decimals at the elementary level remains limited, particularly within the context of the Merdeka Curriculum.

Based on these gaps, this study aims to develop and evaluate a Problem Based Learning-based interactive quiz for fifth-grade students learning fractions and decimals (Mentzer et al., 2023; Pingmuang et al., 2025; Pattanapiboon & Nishizawa, 2024; Qureshi et al., 2025). The novelty of this research lies in integrating contextual mathematical problems, immediate feedback, visual learning supports, and interactive navigation within a web-based quiz that follows PBL principles. This integration is expected to provide a more meaningful, engaging, and student-centered mathematics learning experience.

Method

This study employed a Research and Development (R&D) approach to develop and evaluate a Problem Based Learning (PBL)-based interactive quiz for teaching fractions and decimals to fifth-grade elementary school students. The development process followed the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages. During the analysis phase, observations, teacher interviews, and curriculum document reviews were conducted to identify learning problems, student characteristics, instructional needs, and the availability of school facilities. The findings indicated that students experienced difficulties in understanding fractions and decimals and required more interactive and contextual learning media. These findings served as the basis for designing the instructional product.

In the design and development stages, learning objectives, storyboards, assessment instruments, contextual problem scenarios, and interactive features were prepared in accordance with the Merdeka Curriculum and the principles of Problem Based Learning. The product was developed using the Canva platform as a web-based interactive quiz integrating PBL syntax, including problem orientation, investigation, problem-solving, presentation, and reflection activities. Product validity was evaluated by three validators consisting of a media expert, a mathematics content expert, and a language expert. The validation process assessed aspects of visual design, technical quality, content accuracy, curriculum alignment, language appropriateness, and instructional suitability. Suggestions from validators were used to revise and improve the product before implementation.

The implementation stage involved Grade V students and a mathematics teacher at SDN 57/VII Sei Benteng I as users of the developed product. Practicality data were collected through teacher and student response questionnaires after the learning activities were completed. The instruments used in this study were validated prior to data collection and consisted of validation sheets, practicality questionnaires, observation sheets, and learning achievement tests. Data were analyzed using descriptive quantitative and qualitative techniques. Validity scores were interpreted based on predetermined eligibility criteria, while practicality was calculated from questionnaire responses and converted into categorical scales. The evaluation stage was conducted to determine the overall feasibility of the developed interactive quiz as a learning medium for fractions and decimals in elementary school mathematics.

Results and Discussions

School Context and Needs Analysis

The study was conducted at SDN 57/VII Sei Benteng I, Sarolangun Regency, Jambi Province. The school has implemented the Merdeka Curriculum and is supported by several technology facilities, including Chromebooks, projectors, speakers, and internet access. However, observations revealed that digital learning media were still used minimally in classroom instruction. Mathematics was identified as one of the most difficult subjects for Grade V students due to its abstract concepts, particularly in the topic of fractions and decimals. Teachers mainly relied on textbooks, PowerPoint presentations, learning videos, and occasionally educational platforms such as Quizizz and Wordwall. Nevertheless, these media were considered insufficient to facilitate active learning, critical thinking, and meaningful problem-solving activities.

Table 1. Summary of Learning Needs Analysis

Aspect	Findings
Learning difficulties	Students experienced difficulties understanding abstract mathematical concepts, especially fractions and decimals.
Student engagement	Learning motivation and participation were relatively low during conventional instruction.
Existing media	PowerPoint, learning videos, Quizizz, and Wordwall were occasionally used.
School facilities	Internet access, Chromebooks, projectors, and speakers were available but limited in number.
Teacher expectations	Interactive, contextual, and technology-based learning media capable of fostering critical thinking and communication skills.

The interview results indicated that the existing learning media had not fully supported students' conceptual understanding and active participation. Teachers emphasized the need for interactive learning resources that integrate real-life contexts and promote critical thinking and communication skills. These findings provided the foundation for developing a Problem Based Learning (PBL)-based interactive quiz on fractions and decimals.

Student Characteristics Analysis

The analysis revealed that most Grade V students were approximately 11 years old and were in the concrete operational stage of cognitive development. Students preferred learning through visual representations, contextual examples, group activities, and technology-assisted instruction. Furthermore, students demonstrated high interest in learning activities involving digital devices such as smartphones, laptops, Chromebooks, and projectors. These characteristics became important considerations in designing the interactive quiz media.

Table 2. Student Characteristics

Characteristics	Description
Age	Approximately 11 years old
Cognitive stage	Concrete operational stage
Learning preference	Visual, contextual, and interactive learning
Technology literacy	Familiar with gadgets and internet-based applications
Learning motivation	Higher during technology-assisted instruction

The findings suggest that students require instructional media that combines visual elements, contextual problem-solving activities, and interactive features. Therefore, the developed quiz was designed to align with students' cognitive development and learning preferences.

Product Development Results

Following the ADDIE model, an interactive quiz based on Problem Based Learning (PBL) was developed using the Canva platform. The product consisted of 35 slides containing a cover page, learning objectives, usage instructions, contextual problems, interactive questions, feedback mechanisms, navigation buttons, and supplementary learning materials. The quiz incorporated colorful visual designs, animations, illustrations, and direct feedback features to enhance student engagement and conceptual understanding. The development stage resulted in a web-based interactive quiz integrating Problem Based Learning (PBL) principles for mathematics instruction on fractions and decimals. The product was designed using Canva and incorporated contextual problems, attractive visual elements, interactive navigation, feedback mechanisms, and student-centered learning activities. The main interface of the developed interactive quiz is presented in Figure 1.

Figure 1. Initial Interface of the Problem-Based Learning Interactive Quiz on Fractions and Decimals

As shown in Figure 1, the interactive quiz was designed with child-friendly visual elements, colorful illustrations, and intuitive navigation features to enhance students' engagement and motivation. The interface also clearly presents the learning topic and instructional purpose, thereby facilitating students' readiness before participating in learning activities.

Media Validation Results

Media validation was conducted by a media expert to evaluate visual design, interactivity, conformity with the PBL model, and technical quality. The results showed that the developed media achieved a total score of 44 with an average score of 3.14, categorized as valid.

Table 3. Media Validation Results

Component	Score
Total Score	44
Mean Score	3.14
Category	Valid

The media expert concluded that the product was suitable for implementation after minor revisions. Suggested improvements included adjusting navigation button placement and improving animation smoothness. After revision, the media was considered feasible for classroom use.

Material Validation Results

Material validation was conducted by a mathematics education expert to assess curriculum alignment, content accuracy, contextual relevance, and instructional quality. The validation process resulted in a total score of 56 and an average score of 3.73, indicating a very valid category.

Table 4. Material Validation Results

Component	Score
Total Score	56
Mean Score	3.73
Category	Very Valid

The validator confirmed that the fractions and decimals content was consistent with curriculum objectives and appropriately integrated the Problem Based Learning approach. Additionally, the content was systematically organized and suitable for elementary school students.

Language Validation Results

Language validation focused on grammatical accuracy, readability, clarity, and suitability for Grade V students. The validator reported that the language used in the interactive quiz was communicative, understandable, and appropriate for students' developmental levels. The instructions and contextual problem statements were considered clear and free from ambiguity, supporting students' independent learning.

Teacher Practicality Results

The practicality of the developed media was evaluated through teacher response questionnaires. The results showed a total score of 162 out of a maximum score of 168, with an average score of 3.86, categorized as very good.

Table 5. Teacher Practicality Results

Component	Score
Total Score	162
Maximum Score	168
Mean Score	3.86
Category	Very Good

Teachers indicated that the interactive quiz was easy to use, facilitated mathematics instruction, and increased student engagement. Furthermore, the media effectively supported the implementation of Problem Based Learning activities and encouraged students to participate actively during classroom instruction.

Table 6. Summary of Product Evaluation

Evaluation Aspect	Result	Category
Media Validity	3.14	Valid
Material Validity	3.73	Very Valid
Teacher Practicality	3.86	Very Good
Student Response	Positive	Good
Product Feasibility	Feasible	Highly Feasible

Overall, the evaluation results demonstrate that the developed PBL-based interactive quiz met the criteria of validity and practicality. Expert validators confirmed that the content and media design were appropriate for elementary mathematics instruction, while teachers reported positive perceptions regarding usability and instructional effectiveness. These findings indicate that the developed interactive quiz is suitable for supporting mathematics learning on fractions and decimals among Grade V elementary school students.

The needs analysis revealed that Grade V students experienced difficulties in understanding fractions and decimals, particularly when applying these concepts to contextual situations. In addition, existing instructional media were still limited in facilitating active learning and problem-solving activities. To address these challenges, the developed interactive quiz integrated contextual mathematical problems, visual learning supports, immediate feedback, and structured learning activities based on Problem Based Learning principles. The positive responses obtained from teachers and students indicate that the developed product was relevant to classroom needs and aligned with the characteristics of elementary school learners (Archibald et al., 2026; Arjunamahanthi et al., 2025).

The student characteristics analysis showed that most learners were in the concrete operational stage and preferred visual, contextual, and technology-assisted learning. These findings were reflected in the design of the interactive quiz through the use of illustrations, animations, simple navigation, and real-life mathematical scenarios. Such features are important because students at this developmental stage learn more effectively when abstract concepts are represented through concrete and observable experiences (Adepoju et al., 2026; Gabel et al., 2022). Therefore, the developed product was designed not only to present content but also to accommodate students' cognitive needs and learning preferences (Gopi et al., 2024; Putri et al., 2025).

The validation results further demonstrated the quality of the developed product. Media validation produced an average score of 3.14, categorized as valid, indicating that the visual design, navigation system, and interactive features were appropriate for classroom use. Similarly, material validation achieved an average score of 3.73, categorized as very valid, confirming that the content was accurate, systematically organized, and aligned with curriculum objectives. These findings are consistent with previous studies reporting that well-designed digital learning media can improve instructional quality by enhancing accessibility, usability, and learner engagement (Costa et al., 2025; McIntosh et al., 2023). Furthermore, the integration of contextual problems within the quiz supports meaningful learning by connecting mathematical concepts to students' daily experiences (Mansouri, 2026; Talpur et al., 2024).

The practicality assessment yielded an average score of 3.86, categorized as very good, indicating that teachers perceived the interactive quiz as easy to use and supportive of mathematics instruction. The positive practicality results suggest that the product can be implemented efficiently in elementary school classrooms without requiring complex technical procedures. This finding supports previous research demonstrating that technology-based learning media are more likely to be adopted when they are user-friendly and capable of supporting student participation during learning activities (Ayala-Niño et al., 2024; Rzyankina, 2024). The incorporation of problem orientation, investigation, problem-solving, presentation, and reflection activities within the quiz also reflects the practical application of Problem Based Learning principles in a digital learning environment (Chan & Chiu, 2025; Setyadinsa et al., 2024).

The findings indicate that the developed PBL-based interactive quiz fulfilled the criteria of validity and practicality as an instructional medium for learning fractions and decimals. Compared with previous studies that generally examined digital learning media or Problem Based Learning separately, this study integrates both approaches within a single web-based product, providing a more comprehensive learning resource for elementary mathematics education (Cheon et al., 2026; He, 2023; Patil et al., 2025). Nevertheless, this study was limited to product development and feasibility testing and did not comprehensively evaluate learning effectiveness. Therefore, future studies should investigate the impact of the developed media on students' mathematical achievement, critical thinking skills, problem-solving abilities, and conceptual understanding through broader experimental implementation.

Conclusions

This study successfully developed a Problem Based Learning (PBL)-based interactive quiz for teaching fractions and decimals to fifth-grade elementary school students using the ADDIE development model. The developed product demonstrated satisfactory quality, as evidenced by media validation results categorized as valid, material validation results categorized as very valid, and teacher practicality results categorized as very good. These findings indicate that the interactive quiz is feasible and practical for use in mathematics learning. Therefore, the integration of contextual problem-solving activities and interactive digital features within the developed media has the potential to support student engagement and facilitate a more meaningful understanding of fractions and decimals in elementary school mathematics learning.

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