Development of Problem Based Learning-Oriented Interactive Multimedia to Improve Learning Motivation and Its Implications for Students' Mathematical Literacy

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Abstract

Low learning motivation and poor mathematical literacy remain common issues in mathematics education. Students tend to be passive, less engaged, and struggle to relate mathematical concepts to real-life contexts. The PISA 2022 survey shows that Indonesian students' mathematical literacy is still low, with an average score of 366 and a rank of 70 out of 85 countries. Thus, there is a need for innovative learning that fosters motivation and enhances mathematical literacy. This study aims to develop Problem-Based Learning (PBL) interactive multimedia to improve students' motivation and mathematical literacy in arithmetic sequences and series. The research method used is Research and Development (R&D) with the Alessi and Trollip development model. Validation by content and media experts indicates that the developed multimedia is feasible for classroom use. Students' responses also show high engagement with the PBL-oriented multimedia. Learning with this interactive multimedia demonstrates that students' motivation and mathematical literacy outperform those in conventional learning. Additionally, there is a positive effect of learning motivation on mathematical literacy. Therefore, PBL-based interactive multimedia can be considered an effective alternative to support contextual and meaningful mathematics learning.

Keywords: interactive learning multimedia, *problem based learning*, R&D, learning motivation, mathematical literacy

INTRODUCTION

Learning motivation and mathematical literacy are two crucial aspects that determine students' success in mathematics education. Learning motivation not only drives the achievement of learning objectives (Emda, 2018), but also influences students' adaptive behavior and readiness to face challenges (Dautkalieva, 2020; Filgona, 2020). On the other hand, mathematical literacy is essential in helping students recognize the relevance of mathematics in real-life situations and in developing reasoning and problem-solving skills (Bolstad, 2023; Umbara, 2019). Several studies have explained that mathematical literacy involves the ability to identify, understand, and use mathematics in various contexts (Ugler et al., 2022; Supianti et al., 2022; Andriyani, 2022).

However, the PISA 2022 survey revealed that Indonesian students' mathematical literacy remains low, with an average score of 366 and a rank of 68 out of 81 countries (Kemdikbudristek, 2023). A preliminary study conducted at SMK Negeri 1 Soreang showed that less than 30% of students were able to correctly solve mathematical literacy problems, particularly on the topic of arithmetic sequences and series. This indicates a lack of critical thinking skills and contextual understanding of mathematical concepts.

Many factors contribute to low mathematical literacy, including teacher-centered learning methods (Nurwahid et al., 2022), unengaging teaching approaches (Styawati & Nursyahida, 2017), and the limited use of interactive learning media. Recent research shows that innovative approaches integrating technology and real-life scenarios can enhance students' mathematical understanding

(Maralova, 2024; Krajnc, 2021; Irshad, 2024). Low learning motivation is also a major obstacle, especially among vocational students who study mathematics primarily for graduation or employment purposes (Ryu et al., 2019), in contrast to junior high school students who are more influenced by enjoyable learning environments (Nuraysha et al., 2024).

In the digital era, teachers are expected to utilize technology in the learning process to make it more efficient and engaging (Daniela, 2021). Interactive learning multimedia is one potential solution that can actively engage students and enhance their interest and understanding (Ayudianti et al., 2023; Anggraini et al., 2019). In this context, the Problem-Based Learning (PBL) approach is considered effective in encouraging students to think critically, solve problems, and build learning motivation (Fauzia, 2018; Nicholus et al., 2023). The integration of PBL and interactive multimedia is believed to provide a more meaningful, contextual, and enjoyable learning experience.

Several studies have demonstrated the effectiveness of both PBL and interactive multimedia separately in improving motivation and mathematical literacy (Firdaus et al., 2021; Fajriati & Murtiyasa, 2022; Hamdani et al., 2021). However, research that explicitly integrates both is still limited, particularly at the vocational high school level. Therefore, the development of PBL-oriented interactive learning multimedia is essential to address the challenges of contextual and meaningful mathematics learning.

This study aims to develop interactive learning multimedia based on the Problem-Based Learning approach to improve students' learning motivation and mathematical literacy on the topic of arithmetic sequences and series. It also seeks to investigate the differences in motivation and mathematical literacy between students taught using PBL-based interactive multimedia and those who receive conventional instruction, as well as to examine the influence of learning motivation on mathematical literacy. Accordingly, this research is expected to contribute to mathematics learning innovation that supports the achievement of 21st-century competencies and improves the quality of education at the vocational school level.

METHOD

This study employed a Research and Development (R&D) method using the development model proposed by Alessi and Trollip, which consists of three main stages: planning, design, and development. This model was chosen because it systematically facilitates the design and evaluation of interactive multimedia tailored to students' learning needs. Additionally, the research adopted a mixed-method approach with an Exploratory Sequential Design. The process began with qualitative data collection to develop the instruments, followed by quantitative data collection to test the research hypotheses. The experimental design used to compare outcomes between the treatment and control groups was the Posttest-Only Control Group Design.

The research subjects were drawn from the student population of SMKN 1 Soreang in the 2024/2025 academic year. Participants were selected using purposive sampling based on teacher recommendations. The sample consisted of 35 tenth-grade students from the Electronics Engineering

program, who were considered representative of vocational students facing challenges in learning motivation and mathematical literacy.

The independent variable in this study was the PBL-oriented interactive learning multimedia, while the dependent variables were learning motivation and mathematical literacy. Learning motivation was measured using a closed-ended Likert-scale questionnaire consisting of 30 items—both positively and negatively worded—based on indicators such as the desire to succeed, perseverance, and learning interest. Mathematical literacy was measured using open-ended questions designed in reference to PISA indicators. The test consisted of six items that had been validated and piloted to determine validity, reliability, difficulty level, and discrimination index. Validity was assessed using Pearson correlation, and reliability was measured using Cronbach's Alpha.

The research instruments were developed based on theoretical frameworks and field studies, validated by three media experts and three content experts, and tested through alpha and beta testing. Data collection techniques included questionnaires, tests, observations, interviews, and documentation. Qualitative data were analyzed using triangulation techniques to gain in-depth insights into students' perceptions and experiences during the learning process.

Quantitative data were analyzed using descriptive and inferential statistics. The validity and feasibility of the multimedia were analyzed using mode and median. The Mann-Whitney U test was used to examine differences in learning motivation between groups, while an independent t-test was employed to assess differences in mathematical literacy. Additionally, a simple linear regression analysis was conducted to determine the influence of learning motivation on mathematical literacy, preceded by transforming ordinal data to interval scale using MSI. Assumptions of normality, linearity, and autocorrelation were also tested to validate the regression model.

RESULTS AND DISCUSSION

This study resulted in the development of Problem-Based Learning (PBL)-oriented interactive learning multimedia aimed at improving vocational students' learning motivation and mathematical literacy on the topic of arithmetic sequences and series. The product was developed through the three main stages of the Alessi & Trollip model: planning, design, and development. Validation by subject matter and media experts confirmed that the multimedia is feasible for use, with content, presentation, language, and mathematical literacy components rated as "Feasible" to "Highly Feasible." These results align with the findings of Ayudianti et al. (2023) and Anggraini et al. (2019), which indicate that interactive multimedia enhances engagement and effectiveness in mathematics learning.

Students' responses during beta testing showed that the multimedia was rated "Highly Feasible" by 15 students in the initial test and "Feasible" by 35 students in the field test. They evaluated the content, presentation, and language aspects as meeting their learning needs and supporting active engagement—consistent with Daniela (2021), who argues that technology-based learning improves student participation, particularly in vocational education settings.

The measurement of learning motivation using questionnaires revealed that students in the experimental group using the PBL-oriented multimedia scored higher on average than those in the control group, particularly in indicators such as the desire to succeed, learning needs, persistence, and achievement orientation. The Mann-Whitney U test yielded a significance value of 0.010 (< 0.05), indicating a statistically significant difference between the two groups. This finding supports Ryu et al. (2019) and Filgona (2020), who found that contextual and interactive learning experiences positively impact student motivation—especially in mathematics learning, which is often abstract and less engaging for vocational school students.

In addition, a comparison of students' mathematical literacy through testing showed that although both groups had equivalent initial abilities (as indicated by the pretest t-test result, Sig. = 0.909), the posttest scores of the experimental group were significantly higher (mean = 65.11) than those of the control group (mean = 50.91). The t-test showed a significance value of 0.006, indicating a statistically significant improvement in mathematical literacy following the intervention. This is consistent with the findings of Supianti et al. (2022) and Firdaus et al. (2021), which highlight the effectiveness of problem-based approaches and digital media in enhancing students' reasoning and problem-solving abilities in mathematics.

Furthermore, a simple linear regression analysis demonstrated that learning motivation had a positive influence on students' mathematical literacy, with an R^2 value of 0.404. This reinforces the findings of Dautkalieva (2020) and Fauzia (2018), who emphasized that learning motivation is a significant predictor of students' mathematical literacy achievement, particularly in the context of PISA and contextualized mathematics education.

Thus, this study demonstrates that the integration of interactive multimedia with a PBL approach is not only valid in terms of content and media but also effective in enhancing students' learning motivation and mathematical literacy. The novelty of this study lies in the full integration of multimedia design using Canva and Quizizz platforms with the PBL syntax, which has rarely been developed in the vocational school context. These findings contribute to the advancement of contextual, practical, and relevant digital learning models suited to 21st-century students' needs.

CONCLUSION

Based on the results and analysis of this study, several key findings were identified regarding the development of Problem-Based Learning (PBL)-oriented interactive multimedia to enhance students' learning motivation and its implications for mathematical literacy. The development process followed a systematic framework based on the Alessi & Trollip model, encompassing the stages of planning, design, and development. During the planning phase, the learning needs were identified, students' characteristics were analyzed, and the content was aligned with the curriculum. The design stage focused on developing arithmetic sequence and series materials integrated with PBL syntax, creating a user-friendly interactive interface, and formulating appropriate learning strategies. The development phase involved the comprehensive production of multimedia, including visual, audio,

video, and interactive elements, followed by trials, revisions, and refinements based on expert feedback. Trial results and feedback from both students and teachers indicated that the multimedia enhanced student engagement and deepened their understanding of mathematical concepts in a more contextualized manner. The integration of the PBL approach enabled students to connect mathematical concepts to real-life situations, contributing not only to improved mathematical literacy but also to increased learning motivation.

Furthermore, the study found that the learning motivation of students who participated in PBL-based interactive multimedia instruction was significantly higher than that of students who received conventional instruction. A similar pattern was observed in mathematical literacy outcomes, where students using the interactive multimedia demonstrated higher achievement compared to the control group. Additionally, learning motivation was found to have a positive influence on mathematical literacy, particularly among students in the experimental group. These findings confirm that interactive multimedia designed with a PBL approach is not only effective in enhancing learning motivation but also directly impacts the improvement of students' mathematical literacy.

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