Development of M-Learning-Based Geometry Teaching Materials Oriented Toward Problem-Solving Ability and Self-Regulated Learning in SMK

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Abstract

This study aims to develop geometry teaching materials based on mobile learning (m-learning) and to evaluate their impact on the problem-solving ability and self-regulated learning (SRL) of vocational high school students (SMK). The ADDIE development model was employed in this study, encompassing the stages of Analysis, Design, Development, Implementation, and Evaluation. The research subjects were tenth-grade students at SMK Pasundan 2 Banjaran. Research instruments included a mathematical problem-solving ability test, SRL questionnaire, expert validation sheets, and interview guidelines. Validation results from subject matter and media experts indicated that the teaching materials were categorized as suitable to highly suitable. The Mann-Whitney test results showed no significant difference in problem-solving ability between the experimental and control groups, with an effect size ($d = 0.24$) categorized as weak. The SRL of students in the experimental group was in the developing category. A moderate correlation was found between problem-solving ability and SRL in the experimental group ($r = 0.412$), and a strong correlation in the control group ($r = 0.775$). These findings indicate that the m-learning-based teaching materials made a positive contribution.

Keywords: m-learning, geometry, problem-solving ability, self-regulated learning, ADDIE

INTRODUCTION

The advancement of information and communication technology (ICT) in the era of globalization has brought significant impact to various aspects of life, including the field of education. This technology allows for innovations in the learning process, making it more effective, efficient, and flexible (Ramadan & Arfinanti, 2019). One form of ICT integration in learning is mobile learning (m-learning), which involves the use of mobile devices such as smartphones in teaching and learning activities (Pratama et al., 2018; Hwang & Tsai, 2019).

The implementation of m-learning has been proven to increase student engagement and develop 21st-century skills such as critical thinking, communication, collaboration, and creativity (Yusuf & Ahmad, 2020). At the vocational high school (SMK) level, the application of m-learning is highly relevant because it supports students' needs in understanding academic concepts while also preparing them to face the world of work (Prasetyo, 2022).

Mathematics is a vital subject that serves as a foundation for the development of science and technology (Yaniawati et al., 2019). One of the main competencies in mathematics learning, according to the National Council of Teachers of Mathematics (NCTM, 2000), is problem-solving ability. This skill is considered essential as it equips students to deal with real-life situations in a rational and systematic manner (Kharisma & Asman, 2018).

However, various studies indicate that Indonesian students' mathematical problem-solving skills are still relatively low (Nasution, 2016; Hodiyanto et al., 2020; Davita & Pujiastuti, 2020). The 2018 PISA (Programme for International Student Assessment) data revealed that

Indonesia's mathematics score was only 379, far below the OECD average of 489 (OECD, 2019). The 2022 PISA results showed a further decline to 365 (OECD, 2023), indicating students' low ability to solve contextual problems.

This low performance is caused by several factors, such as the use of conventional learning models that do not develop higher-order thinking skills, the frequent use of routine problems, and the lack of instruction emphasizing non-routine problem solving (Yaniawati, 2022; Kania et al., 2020). In geometry topics, especially trigonometry, students often struggle to understand the concepts and relate them to real-world problems (Rahmawati & Saputra, 2019; Saputra et al., 2020).

In addition to cognitive abilities, affective factors such as self-regulated learning (SRL) also influence success in mathematics learning. SRL refers to students' ability to manage their own learning process, including planning, monitoring, and evaluating their learning activities (Zimmerman & Moylan, 2009; Dewi & Wahyuni, 2020). Research shows that students with high SRL tend to perform better in mathematical problem solving (Khoerunnisa et al., 2021; Kamelia & Pujiastuti, 2020).

In this context, teachers need to develop innovative teaching materials that not only facilitate conceptual understanding but also encourage students' problem-solving abilities and SRL. The development of m-learning-based teaching materials is considered effective because it can provide interactive and flexible learning and supports the visualization of abstract geometry concepts (Huang et al., 2021; Rahmawati, 2021).

Therefore, developing m-learning-based geometry teaching materials oriented toward problem-solving ability and self-regulated learning is a strategic effort to improve the quality of mathematics learning in vocational high schools.

METHOD

General Organization of the Paper

This study employed a research and development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, R. M., 2009). The research was conducted at SMK Pasundan 2 Banjaran. The research subjects were selected through purposive sampling: students from class X TKJ 1 served as the experimental group using m-learning-based teaching materials, while class X TKJ 3 served as the control group using conventional instruction.

Data collection instruments included a mathematical problem-solving ability test, a self-regulated learning (SRL) questionnaire, expert validation sheets, and interview guidelines. Data were analyzed using both descriptive and inferential statistics, including normality tests, homogeneity tests, mean difference tests, effect size, and Pearson correlation.

RESULTS AND DISCUSSION

The m-learning-based geometry teaching materials were developed using the ADDIE model. The stages followed were, Analysis: Observations and interviews were conducted to identify student needs, learning conditions, and student characteristics. Design: The design of m-learning-based materials was created in the form of a Google Site, based on the learning outcomes outlined in the Merdeka Curriculum. Development: The product underwent validation by subject matter and media experts, and revisions were made based on feedback.

An initial trial was conducted with a small group. Implementation: The implementation phase was carried out in the experimental class (using m-learning materials) and the control class (conventional instruction). Evaluation: Evaluation involved mathematical problem-solving tests, SRL questionnaires, and student interviews.

Validation results from four subject matter experts and three media experts indicated that the developed teaching materials fell into the "suitable" to "highly suitable" category in terms of content, presentation, language, and support for problem-solving ability. Although inter-rater reliability showed low agreement (Fleiss' Kappa < 0.2), this was attributed to differences in interpretation.

Effectiveness testing revealed an effect size of 0.24, which is categorized as weak (Cohen, 1988). This indicates that while the use of m-learning teaching materials led to an improvement in problem-solving ability, the improvement was not statistically significant.

The self-regulated learning of students in the experimental group was found to be in the developing category, especially in the aspects of diagnosing learning needs and setting goals. The correlation results showed a moderate relationship between problem-solving ability and SRL in the experimental group ($r = 0.412$), and a strong correlation in the control group ($r = 0.775$).

Interview results supported the quantitative findings. Students reported that the m-learning materials were engaging and flexible, although challenges such as internet access and specific visual layouts were noted.

CONCLUSIONS

M-learning-based geometry teaching materials were successfully developed using the ADDIE model and deemed suitable for use. There was no significant difference in problem-solving ability between the experimental and control groups. The SRL of students in the experimental group was in the developing category, while the control group still required reinforcement. There was a moderate correlation between problem-solving ability and SRL in the experimental group, and a strong correlation in the control group.

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