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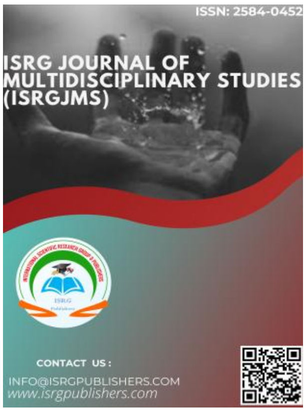

The Effect Of Generative Ai-Integrated Problem-Based Learning Model On Students' Mathematical Problem-Solving Ability In Sletv Material

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Abstract

Mathematical problem-solving ability is one of the core competencies students must master, particularly in the topic of Systems of Linear Equations in Two Variables (SLETV), which requires stepwise reasoning and the mathematical modeling of contextual situations. This study aims to examine the effect of implementing the Problem-Based Learning (PBL) model integrated with generative AI technology on students' mathematical problem-solving ability in the SLETV topic. This research employed a quantitative approach with a quasi-experimental nonequivalent control group design. The population consisted of eighth-grade students at a junior high school, with samples selected through purposive sampling and divided into an experimental group and a control group. The experimental group received PBL instruction enriched with generative AI used as a virtual tutor and a generator of contextual problem illustrations, while the control group received conventional PBL instruction without generative AI assistance. Data were collected through a mathematical problem-solving test based on Polya's indicators and analyzed using an independent t-test after normality and homogeneity assumptions were satisfied. The results show that the mean problem-solving score of the experimental group was significantly higher than that of the control group. These findings indicate that integrating generative AI into the PBL syntax strengthens the stages of problem orientation, exploration of solution strategies, and student reflection on the SLETV topic, thereby resulting in a more optimal improvement of mathematical problem-solving ability compared to conventional PBL instruction.

Keywords: *Problem-Based Learning, Generative AI, Mathematical Problem-Solving Ability, SLETV*

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INTRODUCTION

Mathematical problem-solving ability represents one of the primary goals of school mathematics education, as it encompasses not only conceptual mastery but also higher-order thinking skills essential for students to address real-world challenges (NCTM, 2000; Sanjaya, 2019). Through problem solving, students are trained to comprehend situations, design solution strategies, execute plans, and evaluate their outcomes (Polya, 1973). However, various empirical studies and field observations indicate that Indonesian students' mathematical problem-solving ability remains relatively low, particularly in topics requiring the modeling of contextual situations into mathematical forms, such as Systems of Linear Equations in Two Variables (SLETV). SLETV presents notable difficulties for students because it demands translating contextual problems into two interconnected linear equations and subsequently solving them using substitution, elimination, or combined methods. These obstacles frequently stem from difficulties in problem comprehension and mathematical modeling rather than mere computational errors. Such challenges necessitate learning models that systematically train students to think critically and reflectively, one of which is Problem-Based Learning (PBL). Problem-Based Learning places contextual problems at the core of the learning process, requiring students to actively investigate, discuss, and construct their own knowledge (Arends, 2012; Hmelo-Silver, 2004). The PBL syntax—comprising problem orientation, organizing students for learning, guiding individual or group investigations, developing and presenting artifacts, and analyzing and evaluating the problem-solving process—aligns naturally with Polya's (1973) problem-solving stages. Nevertheless, conventional PBL implementation in classrooms encounters operational challenges, including teachers' limited time for individual feedback, insufficient variety in contextual problem illustrations, and low student learning autonomy during investigations. Emerging generative AI technologies offer promising opportunities to overcome these limitations (UNESCO, 2023). Generative AI can function as a virtual tutor offering real-time feedback, generating varied contextual SLETV problem scenarios, and guiding students through instructional scaffolding without directly revealing final answers. Integrating generative AI into the PBL syntax promises to make problem orientation and investigation more interactive, personalized, and responsive to individual learning needs, thereby potentially improving mathematical problem-solving abilities more effectively than conventional PBL. Consequently, this study aims to examine the effect of implementing a generative AI-integrated PBL model on students' mathematical problem-solving ability in SLETV, comparing it with conventional PBL instruction, and providing theoretical and practical recommendations for adaptive mathematics education (Kemendikbudristek, 2022).

Mathematical problem-solving ability refers to students' capacity to resolve non-routine mathematical tasks that require reasoning, strategic planning, and creativity rather than simple procedural execution (NCTM, 2000). The indicators measuring this ability are based on Polya's (1973) four framework stages: understanding the problem, devising a plan, carrying out the plan, and looking back. These indicators guide the instrument design and rubric evaluation in this study. On the pedagogical side, Problem-Based Learning is a student-centered instructional model that utilizes real-world problems as a context for learning (Arends, 2012). The model consists of five main phases: orienting students to the problem, organizing students for study, assisting independent and group investigation, developing and presenting artifacts, and analyzing and evaluating the problem-solving process (Hmelo-Silver, 2004; Sanjaya, 2019). Through these steps, students build systematic, collaborative, and reflective thinking skills. In parallel, generative AI is an artificial intelligence technology capable of generating original text, visuals, and explanations based on user prompts (UNESCO, 2023). Within mathematics education, generative AI can produce varied contextual tasks, offer step-by-step guidance, and act as a conversational partner assisting students in exploring solution strategies while preserving the teacher's central role as facilitator. To ensure effective learning, generative AI integration must be purposefully designed to foster independent thinking via guiding questions rather than automated answers. This integration is particularly pertinent to SLETV, which involves solving two concurrent linear equations across contextual situations such as pricing, mixture problems, or motion, making it ideal for problem-based inquiry. This study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group setup (Sugiyono, 2021). The design comprised two groups: an experimental group receiving generative AI-integrated PBL instruction and a control group receiving conventional PBL instruction. Both groups completed a pretest prior to intervention and a posttest following intervention to measure mathematical problem-solving ability in SLETV. The research population encompassed all eighth-grade students at a junior high school. The sample was chosen using purposive sampling based on academic baseline equivalence, selecting two intact classes assigned as the experimental and control groups. The measurement instrument was an essay test assessing mathematical problem-solving ability structured around Polya's indicators. The test underwent content validity evaluation by academic experts and reliability verification through pilot testing. Data analysis commenced with prerequisite testing, utilizing the Shapiro-Wilk test for normality and Levene's test for homogeneity of variance. Hypothesis testing was subsequently conducted via an independent sample t-test comparing posttest mean scores between groups, alongside normalized Gain (N-Gain) calculations to evaluate score progression across treatments (Sugiyono, 2021).

RESULTS AND DISCUSSION

The descriptive analysis of pretest and posttest results revealed substantial growth in the experimental group. The experimental group, which experienced generative AI-integrated PBL, achieved a pretest mean score of 52.4 and increased significantly to a posttest mean score of 81.7, yielding an N-Gain score of 0.62 categorized in the moderate-to-high range. Conversely, the control group receiving conventional PBL recorded a pretest mean score of 51.8 and a posttest mean score of 68.3, resulting in an N-Gain score of 0.34 categorized in the moderate range. Baseline pretest scores between the two groups showed no statistically significant difference, confirming initial academic equivalence. However, following the intervention, the experimental group demonstrated a significantly higher posttest mean and N-Gain score compared to the control group. Prior to hypothesis testing, posttest data satisfied all parametric assumptions. The Shapiro-Wilk normality test confirmed normal data distribution across both groups with significance values exceeding 0.05, while Levene's test verified equal variances between groups. Subsequent hypothesis testing via independent sample t-test yielded a p-value below 0.05, establishing a statistically significant difference in mathematical

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problem-solving ability between the two conditions. Consequently, the findings confirm that the generative AI-integrated PBL model exerts a significant positive effect on students' mathematical problem-solving ability in SLETV. This superiority stems from generative AI's enhancement of each phase within the PBL syntax. During problem orientation, generative AI provided dynamic contextual illustrations closely connected to students' daily experiences, facilitating clearer problem comprehension before formal mathematical modeling (Polya, 1973). During independent and group investigations, generative AI functioned as a conversational partner providing scaffolding questions whenever students encountered obstacles, prompting alternative strategies such as substitution or elimination without disclosing final answers. This environment contrasted with the control group, where students encountering difficulties often waited for teacher-led explanations, limiting individual exploration due to time constraints (Arends, 2012). During analysis and evaluation, generative AI provided immediate feedback, identifying procedural missteps in variable substitution or elimination. This instant feedback strengthened students' tendency to review their solutions—a step frequently omitted in traditional settings (UNESCO, 2023). While these outcomes are positive, effective deployment requires precise prompt design and ongoing teacher supervision to ensure AI serves as an active cognitive aid rather than a shortcut for student reasoning.

CONCLUSION

The application of the Problem-Based Learning model integrated with generative AI significantly improves eighth-grade students' mathematical problem-solving ability in Systems of Linear Equations in Two Variables (SLETV). Students instructed through generative AI-integrated PBL achieved a posttest mean score of 81.7 and an N-Gain of 0.62, outperforming students in conventional PBL who recorded a posttest mean score of 68.3 and an N-Gain of 0.34. The integration of generative AI enhances the problem orientation, investigation, and evaluation phases of PBL by offering diverse contextual scenarios, scaffolded prompting, and instant personalized feedback. Based on these findings, mathematics teachers are encouraged to incorporate generative AI into PBL frameworks, taking care to craft targeted prompts and oversee usage so that technology reinforces independent mathematical reasoning. Educational institutions and policymakers should provide training on ethical and effective AI integration in instruction. Future research should examine the applicability of generative AI across other mathematical topics and investigate its impact on affective domains, such as student learning motivation and self-directed learning.

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