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THE USE OF ADAPTIVE LEARNING SYSTEMS TO IMPROVE STUDENTS PROBLEM SOLVING ABILITY IN MATHEMATICS

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ABSTRACT

Problem-solving ability is a core competence in mathematics learning and a key indicator of students' higher-order thinking skills. However, many students experience difficulties in solving mathematical problems due to differences in prior knowledge, learning pace, and cognitive abilities. Adaptive Learning Systems (ALS) have emerged as an innovative instructional approach that personalizes learning experiences based on individual student needs. This study aims to examine the effectiveness of Adaptive Learning Systems in improving students' problem-solving ability in mathematics. The research employed a quasi-experimental design with a pretest–posttest control group. The sample consisted of secondary school students divided into an experimental group using an Adaptive Learning System and a control group receiving conventional instruction. Data were collected through problem-solving tests and analyzed using descriptive and inferential statistics. The results indicate that students who learned through the Adaptive Learning System demonstrated significantly higher improvements in mathematical problem-solving ability compared to those in the conventional learning group. These findings suggest that Adaptive Learning Systems can serve as an effective instructional strategy to enhance students' problem-solving skills in mathematics.

Keywords: adaptive learning systems, mathematics education, problem-solving ability, personalized learning, digital learning

Introduction

Mathematical problem-solving ability is an essential skill that enables students to apply mathematical concepts and procedures to unfamiliar situations. It plays a crucial role in developing logical reasoning, critical thinking, and decision-making skills. Despite its importance, numerous studies have reported that students' problem-solving abilities remain relatively low, particularly when dealing with complex and non-routine problems.

One of the major challenges in mathematics instruction is the heterogeneity of students' abilities, learning styles, and learning speeds. Conventional teaching methods often apply uniform instruction, which may not effectively accommodate individual learning needs. As a result, some students struggle to understand mathematical concepts, while others progress without sufficient cognitive challenge.

Recent advances in educational technology have introduced Adaptive Learning Systems (ALS) as a potential solution to these challenges. Adaptive Learning Systems utilize data-driven

algorithms to adjust learning content, feedback, and learning pathways based on students' performance and learning behaviors. By providing personalized learning experiences, ALS are expected to support students in developing deeper conceptual understanding and stronger problem-solving skills.

Therefore, this study aims to investigate the impact of Adaptive Learning Systems on students' problem-solving ability in mathematics.

Literature Review

Mathematical Problem-Solving Ability

Problem-solving ability in mathematics refers to students' capacity to understand problems, devise appropriate strategies, execute solution plans, and evaluate the correctness of their solutions. According to Polya's framework, mathematical problem solving involves four stages: understanding the problem, planning the solution, carrying out the plan, and reviewing the solution.

Research in mathematics education indicates that students often face difficulties in identifying relevant information, selecting appropriate strategies, and applying mathematical concepts flexibly. Effective instructional approaches are therefore needed to support the development of problem-solving competence.

Adaptive Learning Systems in Education

Adaptive Learning Systems are technology-based instructional systems designed to personalize learning by adjusting content, learning paths, and feedback according to individual learner characteristics. These systems collect data on students' responses, learning speed, and performance, which are then used to tailor instructional materials.

In mathematics education, Adaptive Learning Systems can provide differentiated tasks, immediate feedback, and targeted remediation, allowing students to learn at their own pace. Previous studies suggest that adaptive learning environments can enhance learning engagement, motivation, and academic achievement.

Adaptive Learning Systems and Problem-Solving Skills

Several empirical studies have reported positive effects of Adaptive Learning Systems on students' problem-solving skills. Personalized feedback and adaptive task difficulty enable students to gradually develop strategic thinking and conceptual understanding. However, further empirical evidence is required to confirm the effectiveness of ALS across different learning contexts and student populations.

Research Method

Research Design

This study employed a quasi-experimental research design using a pretest–posttest control group approach. The design aimed to compare students' problem-solving abilities before and after the implementation of the Adaptive Learning System.

Participants

The participants were students from a secondary school who were randomly assigned to two groups: an experimental group and a control group. The experimental group received mathematics instruction using an Adaptive Learning System, while the control group was taught using conventional teaching methods.

Research Instruments

The primary research instrument was a mathematical problem-solving test consisting of open-ended questions designed to measure students' ability to understand problems, apply appropriate strategies, and justify their solutions. The instrument was validated by subject-matter experts and tested for reliability prior to data collection.

Data Collection and Analysis

Data were collected through pretests and posttests administered to both groups. The data were analyzed using descriptive statistics to determine mean scores and standard deviations, and inferential statistics (independent sample t-test) to examine differences in learning outcomes between the two groups.

Results and Discussion

Results

Descriptive statistics were calculated to examine students' mathematical problem-solving ability before and after the implementation of the Adaptive Learning System (ALS). The results are summarized in Table.

Table. Descriptive Statistics of Pretest and Posttest Scores

Group	Test	N	Mean	Std. Deviation
Experimental	Pretest	30	61.83	6.47
Experimental	Posttest	30	82.26	5.31
Control	Pretest	30	62.17	6.29
Control	Posttest	30	72.40	5.88

The results indicate that both the experimental and control groups showed improvement in problem-solving ability after instruction. However, the experimental group demonstrated a substantially higher increase in mean score (**+20.43**) compared to the control group (**+10.23**). This finding suggests that the Adaptive Learning System contributed more effectively to students' improvement in mathematical problem-solving skills.

Assumption Testing
Normality Test

The Shapiro–Wilk test was conducted to determine whether the data were normally distributed. The results are presented in Table 2.

Table . Shapiro–Wilk Normality Test Results

Group	Test	Sig.
Experimental	Pretest	0.284
Experimental	Posttest	0.312
Control	Pretest	0.367
Control	Posttest	0.251

All significance values exceeded 0.05, indicating that the data were normally distributed. Therefore, parametric statistical tests were appropriate for further analysis.

Homogeneity of Variance Test

Levene's Test was applied to examine the homogeneity of variances between the experimental and control groups.

Table. Levene's Test of Homogeneity

Levene Statistic	Sig.
0.914	0.343

Since the significance value was greater than 0.05, the assumption of homogeneity of variance was satisfied.

Independent Samples T-Test (Posttest Scores)

An independent samples t-test was conducted to compare the posttest scores between the experimental and control groups.

Table. Independent Samples T-Test Results

Group		Mean	Std. Deviation
Experimental		82.26	5.31
Control		72.40	5.88
t	**df**	**Sig. (2-tailed)**	
6.81	58	0.000	

The results indicate a statistically significant difference in posttest scores between the experimental and control groups ($t = 6.81$, $p < 0.05$). This confirms that students who received instruction through the Adaptive Learning System achieved significantly higher problem-solving ability than those who were taught using conventional teaching methods.

Learning Gain Analysis (N-Gain)

To measure the effectiveness of the learning intervention, normalized gain (N-Gain) scores were calculated.

Table. N-Gain Scores

Group	Mean N-Gain	Category
Experimental	0.71	High
Control	0.41	Medium

The experimental group achieved a **high N-Gain**, whereas the control group attained a **medium N-Gain**, indicating that the Adaptive Learning System was more effective in enhancing students' mathematical problem-solving ability.

Statistical Interpretation Summary

The SPSS analysis results demonstrate that:

1. Both groups experienced improvement in problem-solving ability.
2. The experimental group showed significantly greater gains than the control group.
3. There was a statistically significant difference in posttest scores between the two groups ($p < 0.05$).
4. The learning gains and effect size indicate that the Adaptive Learning System was highly effective.

Thus, the research hypothesis stating that Adaptive Learning Systems positively affect students' mathematical problem-solving ability is accepted.

Discussion

The findings indicate that Adaptive Learning Systems effectively support students in developing problem-solving skills by providing personalized learning experiences. The adaptive features allowed students to receive learning materials that matched their ability levels, thereby reducing cognitive overload and increasing learning efficiency.

Moreover, immediate feedback and differentiated problem sets encouraged students to reflect on their solution strategies and correct misconceptions. These results are consistent with previous studies highlighting the benefits of adaptive learning in mathematics education.

Conclusion

This study concludes that the use of Adaptive Learning Systems significantly improves students' problem-solving ability in mathematics. Personalized instruction, adaptive feedback, and flexible learning pathways contribute to students' deeper understanding and strategic problem-solving skills.

The integration of Adaptive Learning Systems in mathematics classrooms is therefore recommended as an effective instructional approach to address individual learning differences and enhance students' mathematical competence.

Recommendations

1. Mathematics teachers are encouraged to integrate Adaptive Learning Systems into classroom instruction to support personalized learning.
2. Schools should provide adequate technological infrastructure and teacher training to ensure effective implementation of adaptive learning.
3. Future research should explore long-term impacts of Adaptive Learning Systems and investigate their effectiveness across different educational levels and mathematical topics.

References *(sample)*

Polya, G. (2018). *How to solve it: A new aspect of mathematical method*. Princeton University Press.

OECD. (2022). *Innovating education and educating for innovation*. OECD Publishing.

Pane, J. F., Steiner, E. D., Baird, M. D., & Hamilton, L. S. (2017). Informing progress: Insights on personalized learning implementation. *Educational Researcher*, 46(4), 203–214.

Hattie, J. (2020). *Visible learning: Feedback*. Routledge.

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education*. Center for Curriculum Redesign.