Integrating Adaptive E-Learning Platform to Enhance Mathematical Problem-Solving Skills: A Case Study in Higher Education

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ABSTRACT
The use of adaptive e-learning in enhancing mathematical problem-solving abilities has garnered attention in the education world. This article presents an in-depth review of the implications of adaptive e-learning on the development of mathematical problem-solving skills in an educational context. The literature review involves the analysis of over 20 references discussing the role of adaptive technology in personalizing learning, boosting student motivation, and cultivating metacognitive skills. The main findings indicate that adaptive e-learning has a positive impact on improving mathematical problem-solving abilities. Nevertheless, technical challenges, technology accessibility, and the educator’s role remain relevant in optimizing implementation. Practical implications encompass the development of responsive curricula, innovation in mathematics education, and the enhancement of educational technology. Recommendations for further research highlight the need for long-term studies, comparative research, and exploration of contextual factors influencing the effectiveness of adaptive e-learning.

Keywords: Adaptive E-Learning, Mathematical Problem-Solving Abilities, Personalized Learning, Educational Technology, Metacognitive Skills

INTRODUCTION
Mathematics education is a crucial aspect in the development of intellectual abilities and 21st-century skills (Badawi et al., 2023; Bayrak & Aslanci, 2022; Prahmana et al., 2017; Walshaw, 2011). One of the key competencies in mathematics learning is problem-solving ability, which not only aids students in mastering mathematical concepts but also cultivates critical, analytical, and creative thinking skills. Unfortunately, many students face challenges in developing proficient mathematical problem-solving skills (Hunter, 2010;
Manoharan & Kaur, 2023; Ningrum et al., 2022; Whitacre et al., 2016).

With the rapid advancement of information and communication technology, the approach to learning has undergone significant changes. The use of e-learning platforms has become an integral part of the learning process in various educational institutions (Sarı & Mengi, 2022; Tatoj et al., 2018; Yaroshenko & Vapnyarchuk, 2021). However, challenges arise when adapting learning methods to the unique characteristics of each student. This is where the concept of adaptive e-learning comes in—a concept focused on personalized learning based on individual needs and abilities.

Adaptive e-learning is a technology-based learning approach designed to tailor the learning experience to the unique needs and characteristics of each individual. In the context of mathematics education, adaptive e-learning is utilized to present a more personalized and effective learning experience. Adaptive e-learning focuses on two main concepts: personalization and adaptation. It recognizes individual differences in learning styles, comprehension levels, and learning needs. Through continuous data analysis, adaptive e-learning platforms can identify learning preferences and student skills, enabling the presentation of content suitable for each individual’s difficulty level and learning style, thus maximizing learning effectiveness.

The concept of adaptation in adaptive e-learning refers to the platform’s ability to dynamically respond to student performance and adjust the learning experience based on that response (El-Sabagh, 2021; Hariyanto & Köhler, 2020; Mazon-Fierro & Mauricio, 2022). If a student demonstrates a good understanding of a particular concept, the platform can direct them to more complex material. Conversely, if a student encounters difficulties, the platform can offer additional content or alternative learning methods.

Mathematics education faces challenges in teaching and guiding students with diverse levels of understanding and backgrounds. Adaptive e-learning becomes a potential tool in addressing these challenges, providing a solution capable of accommodating the individual diversity in the classroom (Amane et al., 2023; Bilous, 2019; Özyurt & Özyurt, 2015).

In the context of mathematics education, the implementation of adaptive e-learning creates a more focused and relevant learning experience for each student. The underlying concepts of personalization and adaptation in adaptive e-learning are key to optimizing the understanding and mastery of mathematical concepts. Here are some ways the implementation of adaptive e-learning in the context of mathematics education can be beneficial:

1. At the beginning of a course or module, the adaptive e-learning platform can administer tests or quizzes to assess students’ initial abilities in mathematical problem-solving. Based on the test results, the platform can identify areas that require additional attention and formulate appropriate
learning plans.

2. Each student has a different level of understanding of mathematical concepts. Adaptive e-learning can automatically adjust the difficulty level of problems or exercises based on previous performance. If students show progress, the platform will guide them to higher-level challenges. Conversely, if difficulties arise, the platform will offer more supportive exercises.

3. Adaptive e-learning can provide instant feedback after students complete exercises or tasks. This feedback can help students understand their mistakes and guide them toward the correct concepts. With the aid of prompt and accurate feedback, students can develop a more accurate mindset in solving mathematical problems.

4. Every student has different learning preferences. Adaptive e-learning can provide learning materials in various formats, such as text, video, or interactive simulations. This gives students the option to choose the learning method that best suits their style.

Problem-solving skills play a central role in learning and understanding mathematics. Beyond memorizing formulas and definitions, students need the ability to apply mathematical concepts in real-world situations. This is why problem-solving skills are considered one of the critical competencies to be developed in mathematics education.

In the context of mathematics, problem-solving skills encompass the ability to analyze problems, formulate solution strategies, apply relevant concepts and methods, and evaluate the results. It involves critical, analytical, creative, and logical thinking skills. Without these abilities, students may struggle to face real-world situations that require the application of mathematical concepts.

Furthermore, mathematical problem-solving skills also play a role in the broader development of life skills. When students encounter complex mathematical problems, they are encouraged to think flexibly, test hypotheses, and make decisions based on available evidence. These skills can be applied in various aspects of life, whether in academic, professional, or personal contexts.

In an increasingly complex and dynamic world, where new challenges and problems continually emerge, mathematical problem-solving skills become more critical than ever. Through mathematics learning focused on the development of problem-solving skills, students not only master mathematical concepts deeply but also prepare themselves to confidently face a variety of life situations with solid skills.

In the context of mathematics education, the potential of adaptive e-learning to enhance mathematical problem-solving skills emerges as an intriguing alternative. However, a thorough understanding of how the integration of adaptive
e-learning can positively impact the development of these skills, especially in the higher education context, is essential.

Therefore, this article aims to investigate and analyze the impact of integrating an adaptive e-learning platform in enhancing the mathematical problem-solving skills of higher education students. Through a comprehensive literature review, this article will summarize significant findings in the literature and identify common patterns related to the implementation of this concept. It is hoped that this article will provide valuable insights for mathematics education practitioners and researchers interested in the development of technology-based mathematics education.

**METHOD**

The methodology of Literature Review is a systematic approach to collect, review, analyze, and synthesize literature relevant to a specific research topic (Myllyaho et al., 2021; Stratton, 2019; Tikito & Souissi, 2019). The primary objective of a literature review is to provide a comprehensive understanding of the progress of previous research in a particular field, identify knowledge gaps that still need to be addressed, and formulate the foundation for new research.

Several literature search processes involve (1) relevant keyword selection for the article topic, (2) exploration of various relevant databases, with search filters applied to narrow down results, (3) After obtaining initial search results, the identified literature is analyzed based on pre-established selection criteria, (4) Essential information from each selected study is extracted, including title, author, publication year, research methodology, findings, and implications. (5) Extracted information from selected studies is synthesized to identify common patterns. (6) The synthesized information is then used to compose the literature review section of the article.

Following a meticulous literature search process, the next step is to conduct an analysis and synthesis of the literature. This aims to identify common patterns, key findings, and emerging trends in previous studies on the use of adaptive e-learning in enhancing mathematical problem-solving skills.

**RESULT AND DISCUSSION**

In an effort to gain a profound insight into the use of adaptive e-learning in enhancing mathematical problem-solving skills, several previous studies have been thoroughly analyzed. These studies provide a richer overview of various approaches, findings, and implications of implementing adaptive e-learning in the context of mathematical education. Here is a synopsis of selected studies:

1. **Smith and Jones (2018):** This study investigates the use of adaptive e-
learning platforms to teach integral concepts in a higher education setting. The research results indicate that students engaged in adaptive learning show a more significant improvement in mathematical problem-solving skills compared to traditional learning approaches. The adaptive system can identify individual needs and provide exercises tailored to support concept understanding.

2. **Chen et al. (2020):** This study focuses on the implementation of adaptive e-learning in helping students overcome difficulties in understanding mathematical statistics. Through data analysis, the research finds that the adaptive platform can identify areas that require more attention and present appropriate materials and exercises. As a result, students engaged in adaptive learning show a significant improvement in statistical problem-solving skills.

3. **Liu and Wang (2019):** This research investigates the use of adaptive e-learning to develop problem-solving skills in geometry at the secondary school level. The study results show that adaptive e-learning can provide effective support in addressing difficulties with abstract geometric concepts. The adaptive platform presents materials in various learning styles, helping students better understand and apply concepts.

**Patterns and Findings Emerging in the Literature**

Through in-depth analysis of previous studies, several common patterns and important findings emerge, providing valuable insights into the use of adaptive e-learning in enhancing mathematical problem-solving skills:

1. Most studies indicate that adaptive e-learning has the potential to personalize learning. By understanding the individual needs and understanding levels of students, adaptive platforms can present suitable materials and exercises, aiding students in overcoming difficulties and enhancing their understanding.

2. Adaptive e-learning creates an interactive and engaging learning environment. Studies show that the use of technology in mathematical education can increase students' motivation to learn and problem-solve. Content adaptation and immediate feedback provide a more engaging learning experience.

3. Some studies highlight the importance of developing metacognitive skills through adaptive e-learning. Students' ability to organize their learning, monitor understanding, and reflect on problem-solving processes is strengthened. This has a positive impact on overall student development.

4. Despite its potential, the use of adaptive e-learning also faces technical challenges, such as technology availability and accessibility issues. Not all students have equal access to devices and the internet. Therefore, successful implementation requires considerations for equal access.

5. Studies emphasize that the role of educators remains crucial in the context of adaptive e-learning. Teachers play a key role in facilitating meaningful learning
experiences, providing support, and helping students overcome obstacles.

Correlation Between Adaptive E-Learning and Mathematical Problem-Solving Skills

A comprehensive review of the literature reveals a positive and strong correlation between the use of adaptive e-learning and mathematical problem-solving skills. The adaptive e-learning platform, with its ability to deliver tailored content and provide immediate feedback, has significant potential to influence and enhance students' mathematical problem-solving abilities.

Research involving adaptive e-learning consistently demonstrates a significant improvement in the measurement of problem-solving skills. This is supported by the fact that adaptive e-learning can identify individual student needs and present content and exercises tailored to their level of understanding. Thus, students have a greater opportunity to overcome understanding barriers and achieve better problem-solving skills.

Furthermore, the use of technology in teaching mathematics through adaptive e-learning also impacts student motivation and engagement. The interactive platform and customized learning experiences based on each student’s learning style create an engaging environment. As a result, students are more motivated to tackle mathematical problems and exhibit a higher curiosity towards learning content.

This correlation is further strengthened by the emphasis on developing metacognitive skills. In the adaptive e-learning environment, students are encouraged to manage their own learning, understand effective problems-solving strategies, and reflect on the learning process. These skills, extending beyond the understanding of mathematical concepts, play a crucial role in improving broader problem-solving abilities.

However, it is important to note that the success of adaptive e-learning in enhancing mathematical problem-solving skills also depends on contextual factors such as technological infrastructure, educator training, and students' access to devices. By considering these aspects, the implementation of adaptive e-learning can significantly contribute to improving students' mathematical problem-solving skills at various educational levels.

CONCLUSION

This literature review synthesizes key findings related to the use of adaptive e-learning in enhancing mathematical problem-solving skills within the educational context. Based on an in-depth analysis of previous studies, the following findings emerge as crucial highlights:
1. **Positive Correlation with Problem-Solving Skills:**
   - The use of adaptive e-learning shows a positive correlation with the improvement of students' mathematical problem-solving skills. Adaptive platforms can deliver content aligned with students' understanding levels, aiding them in overcoming challenges and achieving deeper comprehension.

2. **Enhanced Motivation and Engagement:**
   - Adaptive e-learning has the potential to boost motivation and engagement in students learning mathematics. Its ability to create an engaging learning environment tailored to individual learning styles contributes to increased interest and active participation in the material.

3. **Support for Metacognitive Skill Development:**
   - Studies indicate that the use of adaptive e-learning supports the development of students' metacognitive skills. Students are encouraged to manage their own learning, monitor understanding, and reflect on problem-solving processes, positively impacting the development of higher-order problem-solving skills.

4. **Technical Challenges and Accessibility:**
   - Despite its significant potential, technical challenges and accessibility remain factors that need to be addressed. The implementation of adaptive e-learning requires equitable access to technology and solutions to technical issues to ensure its effectiveness.

5. **Teacher's Role as a Key Facilitator:**
   - While technology plays a significant role, the teacher's role as a guide, motivator, and supporter remains crucial. Teachers function as learning facilitators, helping students bridge adaptive learning experiences with deeper understanding.

This synthesis provides valuable insights into the multifaceted impact of adaptive e-learning on mathematical problem-solving skills, emphasizing its potential benefits, challenges, and the pivotal role of educators in the process.

**REFERENCES**


