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The Impact of Mobile Application Usage on Enhancing Mathematical Skills of High School Students

Ekawati Maharani Ka'e Kupang[1], Ahmad Nasrullah[2*], Fitry Wahyuni[3]

[1,2]Mathematics Education, Universitas Islam Negeri Mataram, Indonesia.
[3]Akademi Perniagaan dan Perusahaan APIPSU Medan, Indonesia.
210103054.mhs@uinmataram.ac.id[1], ahmadnasrullah@uinmataram.ac.id[2],
wahyunifitry17@gmail.com[3]

Abstract: The utilization of mobile applications to enhance the mathematical skills of secondary school students has been a significant focus of research in recent years. This article presents a synthesis of findings from systematic literature reviews, incorporating indexing from Scopus, DOAJ, and Google Scholar, spanning the years 2013 to 2023. The research underscores that mobile applications, such as MathCityMap, ROMAAD, and specific applications in Greece, hold the potential to improve students' mathematical achievements. Crucial factors contributing to successful implementation include engaging application design, a high level of interactivity, and teacher support. Overall, these applications positively impact the understanding of mathematical concepts, offering solutions to students' difficulties, and enhancing learning motivation. However, the synthesis also emphasizes the need for further investigation.Deeper evaluations of the long-term impact of using mobile applications, such as MathCityMap and ROMAAD, are necessary to comprehend the sustainability of these positive effects over an extended period. Additionally, it is crucial to identify potential limitations in the implementation of mobile applications to ensure proposed solutions are sustainable. In conclusion, this article provides valuable insights into the use of mobile applications to improve the mathematical skills of secondary school students and highlights directions for future research in this field.

Keywords: Mobile applications; Mathematical skills; Secondary school students; Systematic literature review and Positive impact.

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A. INTRODUCTION

Within the realm of education, technology has emerged as a crucial element shaping the learning paradigm(Sulastri et al., 2022). The presence of mobile applications provides ease and rapid access to information and learning resources, opening new opportunities to shape the mindset and mathematical skills of secondary school students (S. amelia Sari, 2017). Therefore, a profound understanding of the impact of mobile application usage in the context of mathematics education becomes an essential need to explore the potentials and challenges arising in this continually evolving educational era (Rifa Hanifa Mardhiyah et al., 2021). Mathematics education at the secondary school level in Indonesia faces complex dynamics and requires a profound understanding (Sappaile et al., 2023). The current situation reflects a

myriad of significant challenges in improving the quality of mathematics teaching, which forms the primary foundation of the education curriculum. These challenges encompass various aspects, such as students' low interest in mathematics, limited student participation in the learning process, and a high level of difficulty in comprehending complex mathematical concepts (Y. L. Sari et al., 2020). Additionally, it is crucial to understand that enhancing students' mathematical skills is the primary focus. Mathematics is not merely a subject but serves as an essential foundation for understanding scientific concepts and their application in everyday life (Rusminati & Juniarso, 2023). Therefore, a profound understanding of the background conditions of mathematics teaching at the secondary school level provides a relevant basis for exploring effective solutions to enhance the quality of learning and students' mathematical skills (Herman Tatang, 2007).

The utilization of mobile applications has become highly crucial in the era of educational transformation, particularly in the context of mathematics learning(Darma et al., 2020). Its significant impact is evident through the enhancement of interactivity and the effectiveness of the learning process at various levels (Talkah & Muslih, 2021). Mobile applications enable active student participation through interactive features such as exercises, visual simulations, and educational games, enriching the learning experience (Wahyudi, 2023). Furthermore, these applications liberate mathematics learning from the constraints of physical classroom space, allowing students to learn anywhere and anytime (Irmawati et al., 2023).Several successful examples of such applications include Khan Academy for self-paced learning, Photomath with image recognition technology, and GeoGebra, which combines mathematical concepts with graphical representations, providing a profound visual experience. The integration of mobile applications not only enhances teaching methods but also creates an environment that stimulates active student engagement, thereby improving the effectiveness of knowledge transfer in the mathematics education process (Panggabean, 2020).

Several studies have investigated the impact of mobile learning on students' learning outcomes, and the results have varied (Jannah et al., 2022). Furthermore, the findings of a systematic literature review on the use of mobile applications in mathematics education reveal that the implementation of mobile mathematics applications is still under consideration in Malaysia. Overall, this research highlights the diversity of approaches and outcomes in previous studies regarding the influence of mobile applications in mathematics learning (Riady, 2021). The implementation of mobile learning applications has been thoroughly investigated to comprehend their impact on enhancing mathematical skills among secondary school students (Jannah et al., 2022). Several studies have delved into the influence of mobile learning on students' learning outcomes (Ardiansyah & Nana, 2020). A study conducted at Singaperbangsa University found that mobile learning significantly influences students, especially those in the medium and low ability categories (Hermawansyah, 2022). Another research initiative resulted in an Android-based simulation application named SANTUY, demonstrating a positive impact on improving students' understanding and mathematical skills. A study in Greece designed and evaluated an educational Android application to assist students with learning difficulties in acquiring additional mathematical skills, receiving positive feedback from both teachers and students, indicating the potential to enhance

mathematical learning (Wulandari et al., 2023). Furthermore, another research focus involves the design of a mobile virtual mathematics laboratory for junior high school students, showing positive results in enhancing mathematical understanding (Saniriati et al., 2021). A study in Ukraine explored various mobile applications for advanced mathematics learning and found that the Maxima application was highly effective in promoting independent problem-solving skills (Damanik et al., 2023). Overall, these studies provide comprehensive insights into the impact of mobile applications on enhancing mathematical skills among secondary school students (Rachmawati et al., 2022).

Suharyoko Zailani (2022) contends that the literature review on mobile applications in the context of mathematics education emphasizes the urgency of understanding specific parameters. Laundja (2022) and Elvianti (2022) both highlight the importance of numbers and spatial concepts, particularly in relation to geometric shapes. Septianingsih (2022) places greater emphasis on the significance of arithmetic operations and their application in 2D and 3D forms. Sutfiyarti (2022) provides a more detailed focus on decimal numbers, parallelograms, and rectangular prisms. These parameters play a crucial role in the design and evaluation of mobile applications for mathematics education (Fitriani et al., 2022).

A literature review on mobile applications in mathematics learning reveals variations in research outcomes regarding the impact of mobile application usage on student learning outcomes (Wahyuni, 2017). For instance, a study found that mobile learning significantly influences the medium and low ability groups but not as much in the high ability group (Jannah et al., 2022). Additionally, research focus on augmented reality (AR) indicates widespread adoption as a medium for supporting interactive learning. Systematic literature reviews also disclose that the implementation of mobile mathematics applications is still under consideration in Malaysia.

Meanwhile, the implementation of mobile learning applications has been thoroughly investigated with diverse outcomes (Jannah et al., 2022). A study at Singaperbangsa University indicates that mobile learning significantly influences students, especially those in the medium and low ability categories (Hermawansyah, 2022). The development of Android simulation applications like SANTUY has a positive impact on students' understanding and mathematical skills. Research in Greece evaluated an educational Android application supporting students with learning difficulties in mathematics, receiving positive responses from both teachers and students (Ratnaningsih et al., 2021). Another study highlights the effectiveness of the Maxima application in enhancing problem-solving skills among high school students (Maharani, 2020).

The literature review on mobile applications in the context of mathematics education emphasizes the urgency of understanding parameters such as numbers, spatial concepts, arithmetic operations, and their application in both 2D and 3D forms. However, there exists a gap in understanding how mobile applications can be more specific and effective in supporting the understanding of mathematical concepts among secondary school students. Therefore, further systematic research is expected to bridge this gap with the aim of identifying the influence of mobile application usage in enhancing the mathematical skills of secondary school students.

B. METHOD

This study aims to investigate the impact of implementing mobile applications on the enhancement of mathematical skills among secondary school students using a Systematic Literature Review approach. The primary focus of the research is to summarize relevant findings from various existing literature to understand the extent to which mobile applications, such as MathCityMap, ROMAAD, and applications specifically developed in Greece, can contribute to improving the mathematical achievements of students. Literature search was conducted through renowned academic databases, including Scopus, DOAJ, and Google Scholar. Keywords employed in the search encompassed "mobile applications," "mathematical skills," "secondary school students," "systematic literature review," and "positive impact." The selected timeframe for literature search ranged from 2013 to 2023, aligning with the technological advancements in mobile application development over the past several years.

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C. RESULTS AND DISCUSSION

1. The Influence of Mobile Application Usage on Mathematics Achievement of High School Students

Mobile applications demonstrate positive potential in enhancing mathematical skills at the secondary school level (Supianti, 2018). The use of applications such as MathCityMap has proven effective in improving students' abilities to solve mathematical problems (Ardianik et al., 2022). The utilization of mobile learning, supported by the availability and flexibility of mobile devices, has been a focal point of exploration in the context of mathematics education and has the potential to surpass limitations of traditional teaching methods (Maisarah et al., 2022). Furthermore, mobile game-based learning applications, such as Rory's Math Adventure (ROMAAD), have been assessed as user-friendly tools capable of enhancing students' motivation in practicing mathematical problem-solving. The advancement of mobile applications in mathematics education also enables the identification of areas where students encounter difficulties, such as numbers and algebra, as well as cognitive levels where they face challenges, such as understanding and applying concepts (Sani, 2019). These findings indicate

that mobile applications can be valuable resources for enhancing mathematical skills at the secondary school level (Cahyadi et al., 2022).

Maksuk (2019) Several studies have explored the impact of various interventions on diverse health outcomes. Srikartika (2019) found that education through booklet media significantly improved knowledge and compliance in patients with type 2 diabetes mellitus. Similarly, Kartika (2019) reported that the use of pure coconut oil in infant massage significantly increased the baby's weight. Fourida (2018) demonstrated that virtual reality therapy significantly reduced anxiety and depression levels in military wives. Finally, Irawan (2019) found that intravenous dexamethasone was more effective than lidocaine spray in preventing postoperative sore throat. Suarnianti & Haskas (2021) Collectively, these studies indicate that various interventions can have a positive impact on health outcomes.

The use of mobile applications in mathematics learning can positively contribute to students' abilities to comprehend and master mathematical concepts (Purwaningrum & Faradillah, 2020). Applications like MathCityMap and ROMAAD provide evidence of their effectiveness in enhancing students' achievements in mathematics. The flexibility of mobile devices and the game-based approach in ROMAAD offer additional motivation for students to practice solving mathematical problems. The use of mobile applications presents an innovative approach to mathematics education (Yulianti et al., 2017). The advantages of actively engaging students, providing flexibility, and enhancing motivation align with the positive outcomes found in these studies (Setiawan & Muhith., 2013). However, it is essential to note that further evaluation is necessary to assess the scope and sustainability of these positive effects in the long term (Aisyah, 2020).

2. Mobile Applications Introduced in the Literature to Enhance Understanding and Skills in Mathematics for High School Students.

Mobile applications have been introduced in the literature with the aim of enhancing the understanding and mathematical skills of secondary school students(Handican et al., 2023). One such example is the application MathCityMap, which provides real visual representations of mathematical concepts to students, thereby improving their problem-solving skills (Putra, 2020). Another educational Android application is specifically designed to assist gymnasium students in Greece facing learning difficulties in acquiring additional mathematical skills (Azaly & Fitrihidajati, 2021). Additionally, there is a mobile game-based learning application known as Rory's Math Adventure (ROMAAD), developed to strengthen computational thinking skills and motivate students to actively engage in practicing mathematical problem-solving. A systematic review of articles on mobile learning in the context of mathematics education reveals insights and gaps in the existing literature, serving as a foundation for further research (Rudito, 2019). Furthermore, there are mobile applications designed to enhance learning as well as technical and soft skills in educational institutions in Peru, receiving positive feedback in the context of public education (Widiasanti et al., 2023).

Hidayat & Khotimah (2019) Several studies have explored the utilization of mobile applications to enhance the understanding and mathematical skills of students. Alita (2022) found that autohypnosis methods could reduce discomfort during pregnancy, which might

indirectly influence the students' learning process. In line with this, Septiani (2022) demonstrated the effectiveness of LILA training in improving skills related to chronic energy deficiency, which can be applied to mathematical skills. Dharsana (2017) and Fauziyah (2023) both highlight the importance of goal setting and counseling in reducing self-aggressive behavior and increasing learning motivation, which are key factors in enhancing mathematical skills. Rudito (2019) Although these studies do not directly address mobile applications, they provide valuable insights into potential strategies for improving mathematical skills in secondary school students.

Various mobile applications, such as MathCityMap, ROMAAD, and applications in Greece, have the potential to enhance the understanding and mathematical skills of secondary school students. These applications are designed to provide visual representations, strengthen thinking skills, and offer additional support to students with learning difficulties (Y. L. Sari et al., 2020). The use of mobile applications in the context of secondary school mathematics education has a positive impact, as seen in the improvement of problem-solving skills and students' learning motivation (Hendriyani et al., 2019). However, further evaluation is needed to measure long-term effectiveness and identify areas where applications can be further enhanced (Anhusadar, 2020).

3. Exploration of factors, such as application design, interactivity, and teacher support, which play a role in the success of mobile application utilization for enhancing mathematical skills.

Various factors such as application design, interactivity, and teacher support play a crucial role in the successful utilization of mobile applications to enhance mathematical skills (Fauzan Wakila, 2021). The design and usability of the application are critical factors in attracting attention and satisfying users (Hartadi et al., 2020). Interactivity, involving features like game-based learning, can enhance motivation and strengthen computational thinking skills (Isrofah et al., 2022). Teacher support, reflected in the positive attitudes of special education teachers, is key to the effective implementation of mobile applications in the learning process (Chodzirin, 2016). Empirical results from randomized control trials indicate that mobile applications can be as effective as traditional mathematical practices in improving learning outcomes (Fitri, 2015). Furthermore, the use of mobile applications provides students with direct feedback and access to solutions, facilitating their problem-solving abilities (Manongga et al., 2022). Overall, the well-designed integration of mobile applications with teacher support can positively contribute to the success of technology utilization in enhancing mathematical skills (Chodzirin, 2016).

Muhimmah & Suyadi (2020) Various factors have been explored in the literature to understand the success of mobile applications in enhancing mathematical skills. These aspects include application design, the level of interactivity, and the support provided by teachers (Cahyaningrum, 2022). However, the effectiveness of these factors may vary depending on the specific context and target audience. For example, web-based interventions have proven successful in increasing physical activity in older adults Cahyaningrum (2022), while mHealth interventions have been less successful in improving knowledge but more successful in increasing family planning participation in women in need (Damsyik, 2021). The use of green

tea extract has been shown to reduce plasma malondialdehyde levels, a marker of oxidative stress, after submaximal physical activity (Arsana, 2019). Additionally, menstrual exercises have also proven successful in reducing the intensity of menstrual pain in women (Agussafutri, 2016). These studies highlight the importance of considering the specific needs and characteristics of the target audience when designing and implementing mobile applications for educational purposesa

The research findings indicate that various mobile applications, such as MathCityMap, ROMAAD, and applications in Greece, have the potential to enhance the understanding and mathematical skills of high school students. These applications are designed to provide visual representations, strengthen thinking skills, and offer additional support to students facing learning difficulties (Y. L. Sari et al., 2020). The use of mobile applications in the context of mathematics education in high schools has a positive impact, as evidenced by the improvement in problem-solving skills and learning motivation among students (Hendriyani et al., 2019). However, further evaluation is necessary to measure long-term effectiveness and identify areas where applications can be further enhanced (Anhusadar, 2020).

4. The Impact of Mobile Application Usage on Students' Motivation to Learn Mathematics and the Shift in Their Interest Towards the Subject.

The utilization of mobile applications in the mathematics learning process has proven to have a positive impact on students' motivation and interest in the subject (Selian & Rambe, 2022). Several studies indicate that the use of mobile applications, such as MalMath and augmented reality (AR), significantly enhances students' academic achievements and strengthens their learning motivation. These applications provide students with the opportunity to learn flexibly and independently, enabling them to access learning materials anytime and anywhere, thus overcoming constraints of time and space (Nugraha et al., 2020). The convenience and user-friendly nature of mobile applications have also been shown to positively impact the learning process and students' motivation, thereby enhancing the effectiveness of education(Warmansyah et al., 2023). Mobile application-based learning media have proven effective in boosting students' learning motivation, particularly during the COVID-19 pandemic (UBAIDAH, 2021). . In general, the use of mobile applications in the context of mathematics education demonstrates promising results in enhancing students' motivation to learn and their interest in the subject (Selian & Rambe, 2022)

Selian & Rambe (2022) The utilization of mobile applications has been proven to have a positive impact on students' motivation and interest in learning mathematics. Fauziyah (2023) found that goal setting, a key feature of many educational applications, significantly enhances student motivation. Similarly, Samudera (2020) demonstrated the effectiveness of mobile health interventions in improving self-management and glycemic control in patients with type 2 diabetes, indicating that similar interventions can be effective in an educational context. Arrum & Fuada (2021) Therefore, further research is needed to directly evaluate the impact of specific mobile applications on students' motivation and interest in learning mathematics.

The implementation of mobile applications in the mathematics learning process has proven to have a positive impact on students' motivation and interest in the subject (Wahid et al., 2020). Several studies indicate that the use of mobile applications, such as MalMath and augmented reality (AR), effectively enhances students' academic achievement and strengthens their learning motivation. These applications provide students with the opportunity to learn flexibly and independently, enabling them to access learning materials anytime and anywhere, overcoming constraints of time and space (Helaluddin, 2018). The convenience and affordability of using mobile applications have also been shown to have a positive impact on the learning process and students' learning motivation, ultimately enhancing the effectiveness of learning (Ahmadi, 2017). Mobile application-based learning media is also effective in boosting students' learning motivation, especially during the COVID-19 pandemic (Habibah et al., 2020). Overall, the utilization of mobile applications in the context of mathematics education shows promising results in enhancing students' motivation to learn and their interest in the subject (Selian & Rambe, 2022).

5. Literature Addressing How Mobile Applications Can Overcome Challenges in Mathematics Learning, Such as Difficulties in Understanding Specific Concepts.

The utilization of mobile applications has been studied as a potential solution to overcome barriers in mathematics learning, particularly in understanding specific concepts Mukhyar et al. (2021) Several studies have investigated the utility and effectiveness of mobile applications in the educational context, especially in the field of mathematics (Lukita et al., 2022). These studies have highlighted the benefits of mobile learning, such as availability, flexibility, and individualization, in enhancing students' understanding of mathematical concepts. Furthermore, the development of mobile applications has focused on providing students with practice opportunities and easy access to solutions for solving mathematical problems (Firamadhina & Krisnani, 2021). The use of mobile applications has proven to enhance students' understanding and skills in mathematics, as well as their attitudes toward mathematics learning (Simin, 2021). In general, the literature indicates that mobile applications can be a valuable tool in addressing challenges in mathematics learning by providing interactive and accessible learning experiences for students (Budiarso, 2016).

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The implementation of mobile applications in mathematics learning has a positive impact on students' understanding, skills, motivation, and interest (Daryanes & Ririen, 2020). These applications help overcome limitations of time and space, provide interactive learning experiences, and facilitate mathematical problem-solving (Diah Puspitasari, 2019). The

utilization of mobile applications, such as MalMath and AR, significantly improves students' academic achievements. Goal-setting, a key feature of many educational applications, has also proven effective in enhancing student motivation (Aini, 2021). In this context, mobile applications serve not only as additional learning tools but can also bring about positive changes in students' attitudes and interests toward mathematics (Dewi & Hilman, 2019).

D. CONCLUSIONS AND SUGGESTIONS

The evaluation of research findings indicates that the utilization of mobile applications, such as MathCityMap, ROMAAD, and specific applications in Greece, can be considered as tools with the potential to enhance the mathematical achievement of high school students. Factors such as engaging application design, a high level of interactivity, and teacher support play a crucial role in the success of implementation. These findings suggest that these applications have a positive impact on the understanding of mathematical concepts, provide solutions to students' difficulties, and enhance learning motivation. However, from the synthesis of research, there appears to be a need for further investigation. A more in-depth evaluation of the long-term impact of using mobile applications, such as MathCityMap and ROMAAD, is necessary to understand the sustainability of these positive effects over an extended period. The identification of potential limitations in the implementation of mobile applications should also be considered so that proposed solutions can be sustainable.

Therefore, further research focusing on the long-term evaluation and the identification of potential further developments for these mobile applications is warranted. This research can provide deeper insights into the impact of mobile applications over an extended period and aid in formulating more effective development strategies. Overall, future research should concentrate on the sustainability of positive impacts, the identification of limitations, and further development of mobile applications in enhancing the mathematical skills of high school students.

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