

The Use of Technology in Learning Mathematics in Indonesia: A Systematic Literature

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This article presents a systematic literature review on the use of technology in learning mathematics in Indonesia. Through a comprehensive analysis of existing research, this research aims to explore the types of technology commonly used, assess the Effectiveness of technology integration, uncover the associated benefits, and identify the challenges faced in using technology for learning mathematics in Indonesia. This study uses a Systematic Literature Review (SLR) to examine the use of technology in learning mathematics in Indonesia. Computers, online learning environments, mobile apps, virtual reality, augmented reality, games, and e-comics have all been mentioned in studies as tools for teaching mathematics. There hasn't been any specific research on graphing calculators, interactive whiteboards, virtual manipulatives, or 3D printing in Indonesian mathematics education, in any case. Incorporating technology in learning mathematics provides benefits and opportunities by enabling an interactive and dynamic learning experience. Technology also provides access to virtual manipulatives, simulations, and multimedia resources that support students' conceptual understanding and problem-solving skills. However, the effective use of technology also faces challenges, such as unequal access to technology and reliable internet connectivity across Indonesia. Teacher readiness and professional development are essential in using technology effectively, while considering cultural factors and adaptation of technology in the local context. Through this literature review, it is hoped that it can provide insight into integrating technology into mathematics education in Indonesia. These findings will contribute to knowledge about the use of technology in learning mathematics and inform educators, policymakers, and curriculum developers about the types of technology that are commonly used, their Effectiveness, benefits, and challenges faced in their implementation.

Keywords: Technology, Learning Mathematics, Indonesia, A Systematic Literature Review.

1. Introduction

The integration of technology in education has brought significant transformations, including in the field of learning mathematics. Technology offers unique opportunities to improve teaching and learning practices (Hofer et al., 2021), particularly in a subject such as mathematics which often requires visualization, interactive exploration, and problem-solving skills (Al-Mutawah et al., 2019). In the Indonesian context, with the increasing emphasis on educational advancement and the expanding availability of technology, exploring technology in mathematics learning is becoming essential to encourage innovative and effective educational practices. This article presents a systematic literature review on using technology in learning mathematics in Indonesia. The emphasis on advancing education and increasing the availability of technology is increasing. Therefore, it is crucial to explore the potential use of technology in mathematics learning to encourage innovation and Effectiveness in education. The use of technology in learning mathematics in Indonesia has received increasing attention in recent years (Pratiwi & Wiarta, 2021). Advances in technology and the availability of various digital devices have opened up new educational opportunities (Ferri et al., 2020), including in learning mathematics. In facing these challenges and opportunities, many studies have been conducted to investigate how technology integration in mathematics learning has progressed in Indonesia.

The incorporation of technology in learning mathematics raises various benefits and opportunities. This enables interactive and dynamic learning experiences, enabling students to engage with mathematical concepts more meaningfully (Huang et al., 2019; Zengin, 2019). Technology provides access to virtual manipulatives, simulations, and multimedia resources that facilitate visual representation and hands-on exploration, thus supporting students' conceptual understanding and problem-solving abilities (Anderson-Pence, 2020; Shin et al., 2023). In addition, technology can facilitate individual and personalized learning, accommodating a variety of learning styles and speeds (Fonseca & García-Peñalvo, 2019). However, despite the potential benefits, the effective use of technology in mathematics learning also presents challenges. Unequal access to technology and reliable internet connectivity in various regions in Indonesia is obstacles to equitable implementation. Teacher readiness and professional development play a critical role in utilizing technology effectively, which requires educators to be proficient in content knowledge and specific pedagogical strategies for technology integration (Bowman et al., 2022; Love et al., 2020). To guarantee that technology is successfully applied in Indonesian mathematics classes, cultural considerations and the technology's ability to adapt to the local environment must also be considered.

By conducting a systematic literature review, this study aims to contribute to existing knowledge about the use of technology in learning mathematics in Indonesia. These findings will inform educators, policymakers, and curriculum developers about the types of technologies commonly used, their Effectiveness, the benefits associated with their use, and the challenges faced in implementing them. This knowledge can guide future efforts to design effective strategies for integrating technology in mathematics education, aiming to improve students' mathematics learning outcomes and nurture their digital literacy skills. This systematic literature review focuses on using technology in mathematics learning in Indonesia. By answering research questions about the types of technology used, their Effectiveness, the

benefits gained, and the challenges faced, this research sheds light on the current state of technology integration in mathematics education in the Indonesian context. These results will add to the ongoing discussion about using technology in mathematics education and give educators and stakeholders crucial information for creating successful and fulfilling learning opportunities for students in Indonesia.

2. Literature Review

The theory of technology integration in mathematics education emphasizes the effective use of technological tools and resources to enhance the teaching and learning experience in mathematics. It recognizes the potential of technology to support students' conceptual understanding, problem-solving skills, and mathematical reasoning and create meaningful and engaging learning environments. Various types of technology can be used in learning mathematics, such as computers, graphing calculators, interactive whiteboards, virtual manipulatives, online learning platforms, mobile applications, 3D printing, virtual reality, and augmented reality (Buentello-Montoya et al., 2021; Cai et al., 2020; Chen et al., 2020; Moreno-Guerrero et al., 2020). This technology provides several advantages, such as increasing student engagement, providing access to a wide variety of math resources, and helping to develop students' problem-solving skills (Attard & Holmes, 2020; Dockendorff, 2019; Shé et al., 2023). Even so, there are several challenges, such as high technology costs, unequal access to technology among students, and students' convenience. However, the benefits of using technology in learning mathematics still outweigh the risks. With careful planning and implementation, technology can be a powerful tool in helping students learn mathematics effectively.

3. Methodology

This study uses the Systematic Literature Review (SLR) method to examine the use of technology in learning mathematics in Indonesia. SLR is a systematic and comprehensive research method for identifying, evaluating, and integrating research evidence relevant to a particular topic (Xiao & Watson, 2019). A literature search was conducted on Google Scholar and Scopus using the following keywords: "learning mathematics", "education", "technology", and "Indonesia". Data search was carried out in June 2023. The papers you are looking for must meet the following inclusion criteria: (1). Published in scientific journals; (2) speak English or Indonesian; and (3) discuss the use of technology in learning mathematics in Indonesia. The exclusion criteria are research not conducted in Indonesia and book chapters.

The identified articles were analysed to determine their quality. Articles that meet the following criteria are considered to be of high quality: (1) Articles have clear research objectives and methods; (2) Articles have valid and reliable research results; and (3) Articles have conclusions that are relevant to the research objectives.

Research questions (RQ):

1. What types of technology are used in learning mathematics in Indonesia?
2. How effective is the technology used in learning mathematics in Indonesia?

3. What are the advantages or benefits of using technology in learning mathematics in Indonesia?
4. What are the challenges in using technology in learning mathematics in Indonesia?

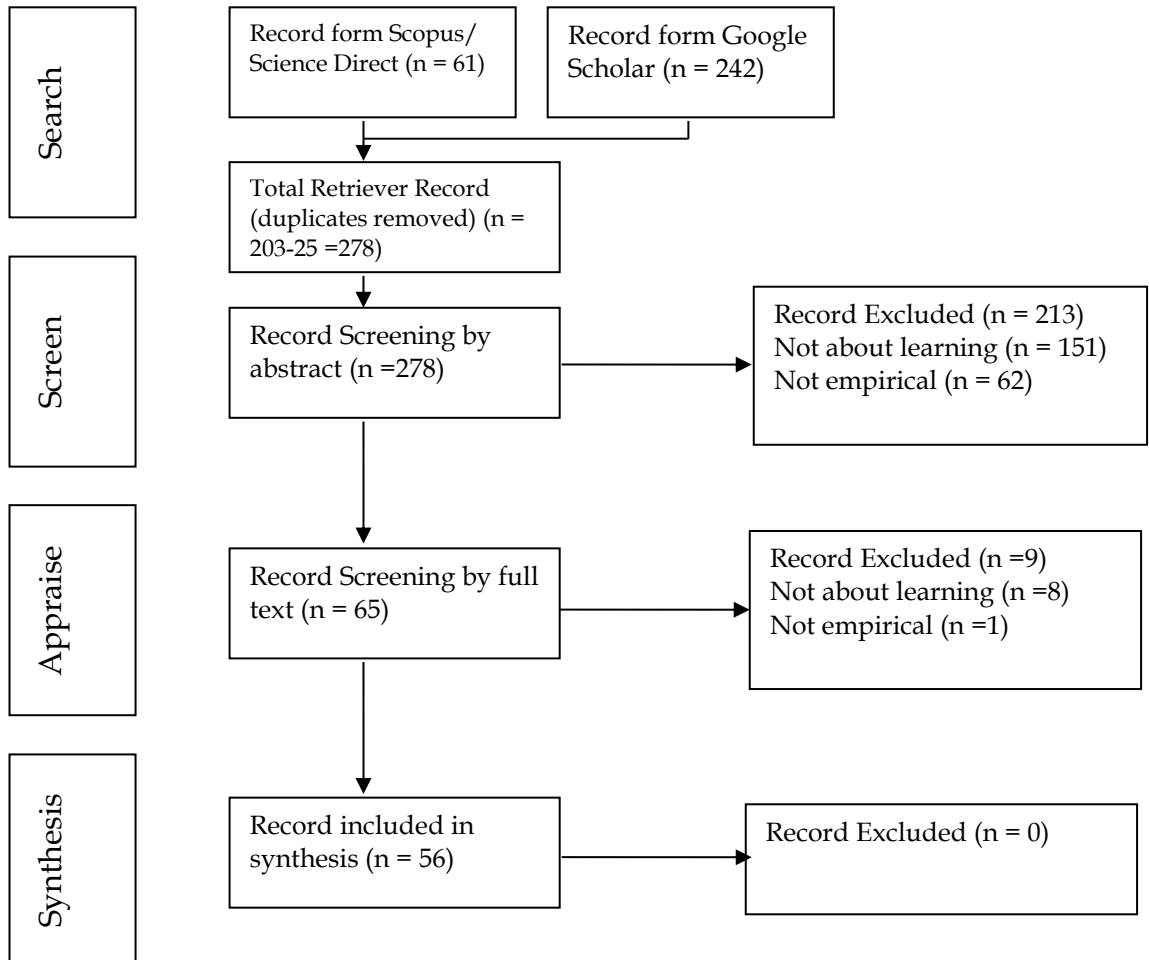


Figure1. Flowchart article selection process, adapted from (Xiao & Watson, 2019)

4. Results

1. The type of technology used in learning mathematics in Indonesia.

Based on the data, 13 references discuss using computers in learning mathematics. In addition, there are 14 references discussing the use of online learning platforms, one reference regarding the use of mobile applications, and two references discussing the use of virtual reality. There are 14 references discussing the use of augmented reality, while games and e-comics each have one reference. However, no references were found discussing the use of graphing calculators, interactive whiteboards, virtual manipulatives, and 3D printing in mathematics

learning in Indonesia. Complete information about the types of technology used in learning mathematics can be found in Table 1.

Table 1. type of technology

Type of technology	Reference
Computers	Asdarina & Fauzi (2023) Firdaus (2016) Gunawan (2014) Juandi et al. (2021) Munawarah (2020) Novikasari (2012) Pratidiana (2021) Rini (2012) Rizki (2012) Sulistyani (2020) V. W. Putri & Suripah (2021) Wirawan et al., (2020) Zayyadi et al., (2017)
Graphing calculators	-
Interactive whiteboards	-
Virtual manipulatives	-
Online learning platforms	Abdullah et al. (2020) Azhari & Fajri (2022) Bhatti & Miranda (2020) Fredlina et al. (2021) Hidayati (2021) Irrawan et al. (2022) M. Huda (2020) Marfuah et al. (2022) Mayasari et al. (2023) Milah et al. (2022) Rahmawati (2021)

	Rusli et al. (2020) Sihotang & Ramadhani (2021) Suroyo & Ismarwati (2006)
Mobile apps	Widiawati et al. (2019)
3D printing	-
Virtual reality	Sulistiyowati & Rachman (2017) Zulfikri (2023)
Augmented reality	Adriansa (2021) Hanafi (2019) Hernita (2023) Khairunnisa & Aziz (2021) M. P. Putri et al. (2014) N. Huda & Purwaningtias (2017) Pranata et al. (2023) Pratama et al. (2023) Rusdi & Syahlan (2019) Sabon et al. (2022) Suliyono et al. (2022) Syahida et al. (2020) Tiyasari & Sulisworo (2021) Yang et al. (2022)
Game	Sukajaya et al. (2016)
e-comic	Adeliyanti et al., (2018)

2. The Effectiveness of technology used in learning mathematics in Indonesia.

The data presented in Table 2 highlights the Effectiveness of use in learning mathematics in Indonesia. Several studies indicate positive results when utilizing technology in the learning process. For instance, the STEM-based inquiry model effectively improved students' critical thinking skills (Pahrudin, 2021). Integrating media in mathematics learning for Grade VII, students has been effective in SMP Negeri 11 Gorontalo (Bito & Masaong, 2023). Adeliyanti et al. (2018) reported that using effective media in their research resulted in 81.25% of students completing the learning test successfully, with 94% expressing satisfaction with the practicality of the approach through a questionnaire.

Implementing the PjBL model also demonstrated Effectiveness, as evidenced by improved written exam results and successful completion of project assignments (Rarasati et al., 2022). Tong et al. (2021) found that visual representations in an enhanced learning environment significantly contributed to students' more effective math learning. Additionally, Milah et al. (2022) emphasized that technology played a vital role in fostering effective, creative, and innovative learning in mathematics, serving as an alternative medium for education. Moreover, Khotimah et al. (2021) observed positive learning outcomes among students in Indonesia through the implementation of STEM education. These findings collectively emphasize the beneficial impact of technology in enriching mathematics education and fostering a more effective and engaging learning environment.

Table 2. Effectiveness of technology

Effectiveness of technology	Reference
The STEM-based inquiry model demonstrated Effectiveness in enhancing students' critical thinking skills.	Pahrudin (2021)
Integrating media in mathematics learning for Grade VII students at SMP Negeri 11 Gorontalo proved effective.	Bito & Masaong (2023)
Using effective media in this research, involving 32 students in the learning test, resulted in an 81.25% completion rate. Additionally, the questionnaire indicated that 94% of students found it practical.	Adeliyanti et al. (2018)
The Effectiveness of implementing the PjBL model is evident from the written exam results and the completion of project assignments.	Rarasati et al. (2022)
Visual representations in an enriched learning environment enable students to learn math more effectively.	Tong et al. (2021)
The study's findings highlight the essential role of technology in fostering more effective, creative, and innovative mathematics learning, providing an alternative medium for education.	Milah et al. (2022)
STEM education in Indonesia was effective in enhancing students' learning outcomes.	Khotimah et al. (2021)

3. Advantages or benefits of using technology in learning mathematics in Indonesia

Table 3. Displays data related to Advantages or benefits. According to Cahyono (2019), digital technology can potentially support teachers in facilitating the process of learning mathematics outdoors. Learning using flash animation helps students understand abstract mathematical concepts significantly, as revealed by Salim & Tiawa (2015). Providing better access to technology will help address some challenges associated with student engagement in mathematics learning at the secondary school level in Indonesia, as presented by Abidin, Mathrani, & Hunter (2017). Collaborative learning methods integrated with technology provide better results than individual learning methods, as found by Wawan et al. (2018).

Table 3. Advantages or benefits

Advantages or benefits	Reference
Teachers may benefit from using digital technology to aid with outdoor math instruction and learning.	Cahyono (2019)
Learning using flash animation immensely helps students understand abstract mathematics significantly.	Salim & Tiawa (2015)
Addressing issues with student involvement in mathematics learning in Indonesian secondary school groups will be more accessible by improving access to technology.	Abidin, Mathrani, & Hunter, (2017)
The collaborative learning approach that incorporates technology yields superior outcomes to the individual learning approach.	Wawan et al. (2018)

4. Challenges in the use of technology in Learning mathematics in Indonesia

The data presented in Table 4 highlights the challenges faced in using technology in mathematics education in Indonesia. The first challenge pertains to the lack of access to technology in certain schools, particularly in rural areas, which hinders the effective integration of technology into the learning process. Funding issues are also identified as a significant obstacle, especially for schools in rural areas with limited financial resources compared to their urban counterparts. Another challenge highlighted in the data is the inadequate training of teachers in utilizing technology for mathematics learning, which can impede the successful implementation of technology in the classroom. Lastly, the data indicate that school infrastructure plays a crucial role, and limited access to facilities such as internet connectivity and power outlets further hampers the use of technology in mathematics education. These challenges underscore the need for addressing various aspects, including accessibility, funding, teacher training, and infrastructure, to leverage technology effectively in mathematics learning in Indonesia.

Table 4. Challenges in the use of technology

Challenges in the use of technology	Reference
The lack of access to technology in several schools in Indonesia, especially in rural areas, makes it difficult to use technology in learning. In addition, funding issues are an obstacle, especially in schools in rural areas which may have limited funds compared to schools in urban areas.	Guntur et al. (2019)
Inadequate teacher training for the use of technology in mathematics learning.	Radiamoda (2022)
School infrastructure is limited in supporting the use of technology, including internet access and power outlets.	Abidin, Mathrani, Hunter, et al. (2017)

5. Discussion

1. The type of technology used in learning mathematics in Indonesia.

Based on the data found, several studies have discussed the use of technology in learning mathematics in Indonesia. In particular, there is research that examines the use of computers as a means of accessing interactive mathematics resources, simulations, and mathematics learning software. The article written by Xie et al. authors discusses the use of computer-assisted instruction (CAI) in mathematics education; they argue that CAI can be an effective tool for enhancing mathematics learning, and they provide evidence from research to support their claims (Xie et al., 2020). In an article by Zhang & Wang, the authors examined the impact of computer simulations on students' mathematical achievement. They found that students who used computer simulations had higher math achievements than students who did not use computer simulations (Zhang & Wang, 2020).

In addition, the use of online learning platforms has also become a concern in learning mathematics in Indonesia. This platform provides access to materials, exercises, and interactions facilitating online mathematics learning. This finding is consistent with research conducted by Holubowicz, which states that online interactive sessions provide access to materials, exercises, and interactions (Holubowicz, 2021). Other findings say that online learning has become a vital learning method for students (Mahoney & Hall McManus, 2022). From these findings, it can be concluded that online education has become necessary in learning in this era.

Furthermore, one study discusses the use of mobile applications in learning mathematics in Indonesia. Mobile applications are portable and personally accessible tools for students to deepen their understanding of mathematical concepts through interactive exercises and customized learning materials (Widiawati et al., 2019). In the context of learning mathematics in Indonesia, research also describes the use of Virtual Reality (VR) technology. Through 3D

simulations, visualizations, and more realistic visual experiences, students can experience immersive and interactive mathematics learning (Sulistiyowati & Rachman, 2017; Zulfikri, 2023). In addition, augmented reality (AR) has also become the focus of research in learning mathematics in Indonesia. In several studies, AR is used as a technology that combines digital elements with the real environment, enabling students to interact with mathematical objects visually and interactively.

From these findings, it can be concluded that technology is increasingly used in learning mathematics in Indonesia to enhance student interaction and experience in understanding mathematical concepts. One of the technologies used is a mobile application, which allows students to study mathematics privately through interactive exercises and customized learning materials. In addition, Virtual Reality (VR) technology has also been used in mathematics learning. Through 3D simulations and more realistic visualizations, students can experience learning mathematics in a more immersive and interactive way. Virtual and augmented reality technologies increase student interactivity and interest in mathematics education (Demitriadou et al., 2020).

Meanwhile, Augmented Reality (AR) is also the focus of research in learning mathematics in Indonesia. AR allows students to interact visually with mathematical objects and integrate digital elements with natural environments, enriching learning experiences. The study conducted by Pellas & Kazanidis states that AR applications enable intuitive learning scenarios and enhance the user's interactive experience (Pellas & Kazanidis, 2019). Augmented reality allows students to interact visually with mathematical objects and integrate digital elements with natural environments (Chao & Chang, 2018). These findings show that technology has significantly contributed to learning mathematics in Indonesia by creating more engaging, interactive and effective learning experiences for students.

Furthermore, the research discusses using games in learning mathematics in Indonesia (Sukajaya et al., 2016). Mathematical games developed digitally can motivate students and make learning mathematics more fun while developing an understanding of mathematical concepts. In addition, there is also research that describes the use of e-comics in learning mathematics in Indonesia. E-comics present interesting mathematical content in electronic comics that can enrich students' understanding of mathematical concepts (Adeliyanti et al., 2018). However, no research studies were found discussing their use in learning mathematics in Indonesia for graphic calculators, interactive whiteboards, virtual manipulatives, and 3D printing.

Technologies such as computers, online learning platforms, mobile applications, virtual reality, augmented reality, games, and e-comics have been proven to increase students' understanding of mathematics, increase learning motivation, and create more exciting and interactive learning experiences. This technology also offers challenges in improving teacher skills, accessibility, and supporting infrastructure that must be considered in implementing effective mathematics learning with technology. The data type of technology shows that research on the use of technology for learning mathematics in Indonesia is still developing. Many studies have been conducted to examine the Effectiveness of using technology for learning mathematics (Cullen et al., 2020; Ran et al., 2022; Thurm & Barzel, 2020), But there is still much research that needs to be done to increase our understanding of the most effective

ways to use technology for mathematics learning.

Based on the available data, no research has been found that specifically addresses the use of technology such as graphic calculators, interactive whiteboards, virtual manipulatives, and 3D printing in mathematics learning in Indonesia. This shows that research and documentation related to using this technology in the context of learning mathematics in Indonesia is still limited. However, this also provides opportunities and challenges further to explore these technologies' use in learning mathematics. Further research and exploration are needed to understand the potential and benefits of using this technology to improve students' understanding and math skills in Indonesia.

2. The Effectiveness of technology used in learning mathematics in Indonesia.

The data shows a growing body of evidence to suggest that technology can be an effective tool for learning mathematics. However, it is essential to note that not all studies have found the same results. For example, some studies have found that technology can effectively improve students' critical thinking skills (Burbules et al., 2020; Kevin A. Artuz & B. Roble, 2021), while others have found that it has no significant impact.

Overall, the data suggest that technology can be an effective tool for learning mathematics, but more research is needed to determine the best ways to use it.

Here are some additional points to consider:

1. The type of technology used may impact its Effectiveness. For example, some studies have found that interactive learning environments can be more effective than traditional textbooks.
2. The way that technology is used may also impact its Effectiveness. For example, some studies have found that technology is more effective when used in a collaborative learning environment.
3. The individual student may also impact the Effectiveness of technology. For example, some students may be more motivated to learn with technology than others.

It is essential to consider all of these factors when determining whether or not to use technology in mathematics instruction.

3. Advantages or benefits of using technology in learning mathematics in Indonesia

The data shows several advantages or benefits to using technology in mathematics education. These include:

1. Technology can help to make mathematics more engaging and interactive. Technology can create simulations, animations, and other interactive learning experiences to help students visualize and understand mathematical concepts.
2. Technology can help to provide students with more individualized instruction. Technology can create personalized learning plans and activities tailored to each student's needs.

3. Technology can help to make mathematics more accessible to all students. Technology can give students access to resources and learning experiences they may not otherwise have.

The data also shows a positive relationship between the use of technology and student engagement in mathematics learning (Lo & Hew, 2021; Marpa, 2020). This suggests that providing better access to technology can help to improve student engagement in mathematics and lead to better learning outcomes.

It is important to note that technology is not a panacea for all mathematics education challenges. However, the data suggests that technology can be a valuable tool for improving student engagement and learning outcomes in mathematics.

Here are some additional points to consider:

1. The type of technology used is essential. Some technologies are better suited for certain types of learning activities than others.
2. The way that technology is used is also essential. For example, technology can deliver content, facilitate collaboration, or provide feedback.
3. The individual student also plays a role. Some students are more motivated to learn with technology than others.
4. It is essential to consider all these factors when determining how to use technology in mathematics instruction.

4. Challenges in the use of technology in Learning mathematics in Indonesia

The data shows some challenges to using technology in mathematics education in Indonesia. These challenges include:

1. Lack of access to technology. This is the most fundamental challenge, as it limits the opportunities for students to learn mathematics using technology.
2. Lack of funding. This can make it difficult for schools to purchase and maintain technology and limit the availability of training for teachers.
3. Inadequate teacher training. Even if schools have the technology, teachers may not be able to use it effectively if they do not have the training they need.
4. Inadequate infrastructure. Even if schools have the technology and the teachers are trained, the infrastructure may not be in place to support the use of technology.
5. Cultural factors. Some cultural factors can also challenge the use of technology in mathematics education.

These challenges can make it difficult for schools in Indonesia to integrate technology into their mathematics curriculum effectively. However, several things can be done to address these challenges, such as:

1. Increased funding for technology in schools. This would allow schools to purchase and maintain technology and provide funding for teacher training.
2. Initiatives to improve teacher training in the use of technology (Trust & Whalen, 2020). This would help teachers to learn how to use technology effectively in their mathematics lessons.
3. Investments in infrastructure to support the use of technology (Marks & Thomas, 2022). This would ensure that schools have reliable internet access and electrical outlets they need to use technology.
4. Education about cultural factors that may pose challenges to the use of technology. This would help to raise awareness of these challenges and how they can be addressed.

By addressing these challenges, schools in Indonesia can better use technology to improve mathematics education.

6. Conclusion

Based on the data findings, various types of technology have been used in learning mathematics in Indonesia. Several studies have addressed using computers to access interactive mathematics resources, simulations, and learning software. In addition, online learning platforms, mobile applications, virtual reality, augmented reality, games, and e-comics have also been used in mathematics learning. However, no research has been found that specifically addresses the use of graphing calculators, interactive whiteboards, virtual manipulatives, and 3D printing in the context of learning mathematics in Indonesia. The use of technology in learning mathematics can be an effective tool. However, it should be noted that research results are not always consistent. Some studies have found that technology can improve students' critical thinking skills, while others have seen its impact insignificant.

Further research is needed to determine the best way to utilize technology in learning mathematics in Indonesia. Technology in learning mathematics provides advantages. Simulations, animations, and other interactive learning experiences make learning mathematics more exciting and interactive. Technology also enables more personalized learning and greater accessibility of learning materials. In addition, technology has been proven to increase student engagement in learning mathematics. However, there are several challenges in using technology in learning mathematics in Indonesia. Barriers to access to technology, lack of funding, inadequate teacher training, and inadequate infrastructure must be overcome. Cultural aspects can also affect the use of technology in learning mathematics. Overcoming this challenge requires joint efforts from the government, schools and relevant stakeholders to create a learning environment that supports the effective use of technology. This article shows that using technology in teaching mathematics in Indonesia significantly increases student engagement and understanding. However, tackling existing challenges is essential to ensure technology is used more effectively in mathematics learning.

This knowledge will help design more effective strategies for integrating technology into mathematics education to improve students' mathematics learning outcomes and enhance their

digital literacy skills. With a focus on studying the use of technology in mathematics learning in Indonesia, this systematic literature review aims to provide educators and stakeholders with valuable insights in shaping effective and meaningful learning experiences for students in Indonesia.

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