

The Effect of the Utilization of Technology in Mathematics Learning on the Learning Outcomes of Elementary School Students

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ABSTRACT

This article discusses how technology is used in elementary school classrooms to teach math. In the context of 21st-century education, using technology in schools is a critical need to improve the quality of learning. Projectors, interactive whiteboards, interactive software, and educational films are just a few of the many advanced tools and platforms made possible by digital breakthroughs that have the potential to revolutionize the way elementary school students learn math. The study highlights how technology can improve student understanding and engagement by visualizing abstract ideas, offering individualized exercises, and providing instant feedback. The role of technology in simplifying abstract concepts makes it an effective tool for teachers and students. According to the study, using technology to teach elementary school math provides more flexibility, accessibility, and engagement than traditional teaching techniques. Using digital media to visualize ideas helps students better understand challenging content. The proper application allows teachers to adapt the learning method to the needs of individual students. According to the article's conclusion, elementary school students can learn math more efficiently, interactively, and fun way if technology is used appropriately. This can ultimately lead to better learning outcomes. This study makes an essential contribution to developing innovative technology-based learning strategies.

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1. INTRODUCTION

Students' understanding of fundamental ideas has changed significantly due to the use of technology in teaching mathematics in elementary schools. This change reflects a new dynamic in the teaching and learning process that increasingly emphasizes digital integration as the primary means of supporting learning. This transformation aligns with bibliometric

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findings that show a significant increase in publications related to gamification and game-based learning at the primary school level, especially from 2016 to 2022 [2],[3].

Students can learn more dynamically and happily with the help of gadgets such as tablets, PCs, and educational apps. Technology allows information to be delivered more tangibly and visibly. For example, animations can be used to illustrate geometry or fractions. This makes it easier for students with difficulty with abstract mathematics to realize how the ideas are used in everyday situations [1]. The presence of technology allows learning to be more contextual and relevant to the real world. Technology not only enhances understanding but also enhances students' enthusiasm for learning. Because they feel like they're playing, students are more engaged in learning math when using game-based, or *gamified*, apps. For example, apps like Mathletics and Kahoot! Offer challenges that encourage students to solve problems and earn points.

Recent-meta-analyses show that gamification consistently positively impacts mathematics students' cognitive and affective domains [4]. Thanks to this technology, student learning outcomes improve due to increased activity and their enthusiasm for learning [1]. In addition, students can learn independently and at their own pace thanks to technology. Students no longer have to wait for the teacher to return information they don't understand because they can learn it using instructional videos and internet resources like *Khan Academy* or *Ruangguru*. This is very helpful for students with different learning styles. Other students who get information faster can move on to the following subject, while others who are still struggling can continue learning until they understand it [2].

This flexibility opens up opportunities for more inclusive and personalized learning. While technology has many advantages, there are also some drawbacks to be aware of. Among them is the risk that students will increasingly rely on technology to help them in math. Without adequate supervision, students will become more reliant on problem-solving software or calculators than they are fully aware of the material. Additionally, students may be less engaged in social relationships when using technology, especially if they are self-taught using digital devices [3],[4]. Therefore, the right approach should be used to balance the use of technology in mathematics education. Teachers need to design a balanced integration between technology and traditional methods so that the social and conceptual aspects of students are maintained. Teachers should create lessons integrating technology with traditional teaching strategies such as project-based learning or group discussions [5]. This approach refers to the TPACK framework, which holistically combines pedagogy, content, and technology [6]. Thus, integrating technology in mathematics learning requires selecting the right tools and a deep understanding of pedagogical principles and the needs of individual students.

2. METHOD

This study aims to investigate and evaluate how using technology in mathematics learning affects the learning outcomes of elementary school students using library research methodologies. This methodology was chosen because it allows researchers to gain an in-

depth understanding based on synthesizing relevant literature published previously. Multiple related literature sources were reviewed to conduct this research, including academic publications published in the last five years, research reports, scientific journals, textbooks, and seminar sessions [6]. The selected literature discusses the use of educational technology, interactive learning materials, and software or applications for mathematics, and how this impacts students' understanding of ideas and the achievement of learning objectives in primary school [7].

Inclusion criteria include studies focusing on the elementary school level, using digital-based technology, and measuring impact on learning outcomes. To collect data, literature sources were found using online databases including Google Scholar, DOAJ, and university digital libraries. The collected data is then incorporated into a qualitative descriptive-analytical analysis, which involves summarizing results found in the literature, finding trends, and formulating conclusions about the relationship between improved mathematics learning outcomes and technology use [8]. Analysis steps are carried out systematically to identify patterns, consistent findings, and gaps in existing research. The study examined several topics, including the types of technology used (such as instructional videos, exercise apps, or educational games), how they are incorporated into the learning process, and how they affect student engagement, motivation, and academic performance.

Using this methodology, this study will provide a comprehensive overview of how well technology can be used to improve the standard of mathematics teaching at the elementary school level [9]. The findings of this approach are expected to be the basis for recommendations for education practitioners in integrating technology effectively in the classroom.

3. RESULTS AND DISCUSSION

The use of technology in elementary school mathematics learning greatly influences students' learning outcomes. This reflects the importance of innovative and technology-based teaching strategies to increase learning effectiveness. According to meta-analysis research, digital learning resources can improve students' motivation and understanding of math. One of the main factors in increasing students' enthusiasm for learning is to choose media that suits their respective characteristics [10]. Thus, the selection and adjustment of technology media must consider learning styles, ability levels, and student preferences to optimize the impact.

In addition, integrating learning technology makes learning more interesting and dynamic. This can be seen from the increased participation of students in the learning process when interactive technologies such as applications or simulations are used appropriately. In addition to hardware, educational technology also includes software and other learning materials that can be used to improve the quality of learning [11]. Educational applications such as interactive videos, exercise-based software, and gamification have been proven to help visualize abstract concepts that were previously difficult for students to understand.

However, it's essential to consider the pitfalls of integrating technology into the classroom. While technology has many benefits, it can lead to dependency and negatively

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impact student well-being if not used responsibly. This dependence can reduce students' critical thinking and problem-solving skills if they rely too much on technology to answer questions without understanding the process. Therefore, to ensure the best learning outcomes, a balanced approach to technology implementation is needed [12]. Teachers play an essential role in directing and supervising the use of technology to stay within a healthy and educational pedagogical corridor.

3.1. The Positive Influence of Technology Integration on Mathematics Learning

The application of technology in mathematics learning at the elementary school level significantly influences the quality of student learning outcomes. Technology is a visual aid and a means to build a more interactive and enjoyable learning experience. Various studies show that the use of interactive apps, educational games, and animated media helps bridge the gap in students' understanding of abstract concepts in mathematics [13][14][15]. In the context of modern learning, technology has become a catalyst that encourages students to more actively explore mathematical ideas independently.

Furthermore, technology allows for differentiation of learning. With the help of devices such as tablets and laptops, students can learn according to their rhythm and learning style. Some platforms even provide instant feedback and automatic tracking of student progress. This makes it easier for teachers to monitor learning outcomes while supporting students who experience cognitive barriers in a more personal and adaptive manner [16].

3.1.2. Improved Conceptual Understanding

The use of simulation-based applications, such as GeoGebra, has proven effective in providing a concrete understanding of geometric and visual-spatial ideas. Students not only see but also "experience" mathematical concepts directly, resulting in a shift from abstract learning to constructive and contextual understanding.

3.1.3. Increased Motivation and Interest in Learning

Educational games and video tutorials have significantly transformed the approach to learning math. The visual elements, challenges, and interactions inherent in educational games make learning more enjoyable. These fun learning situations foster curiosity and reduce the math anxiety that students commonly experience. In addition, media such as animated videos provide a more understandable visualization of complex ideas, thus helping students who have learning difficulties.

3.1.4. Facilitation of Independent Learning

Platforms like Khan Academy and Ruangguru provide flexible, personalized, student-oriented learning spaces. Students are not bound by the speed of the class in general, but can repeat the material according to their comprehension needs. The independent learning these platforms offer encourages students to take responsibility for their learning process, an essential competency in 21st-century learning.

3.1.5. Teacher's Support in Delivering Material

Technology expands the teacher's choice of methods for delivering mathematics material. Digital presentations, interactive simulations, and educational films make abstract concepts more concrete and interesting. Teachers can design diverse activities according to students' abilities. Thus, technology reinforces pedagogical strategies, not substitutes for teachers.

3.1.6. Development of Problem-Solving Skills

Problem-solving applications provide logic and analytical challenges that encourage the development of critical thinking skills. Students are invited to find answers and understand the process and solution strategies. In addition to improving academic competence, this strategy fosters soft skills such as perseverance, decision-making, and adaptability in solving daily problems [17].

3.2. Potential Negative Impacts of the Use of Technology in Mathematics Learning

While integrating technology in primary education offers a range of benefits, it is essential to critically examine the potential negative impacts that can arise, particularly in mathematics learning. One of the main concerns is the decline in independent thinking skills and mastery of basic arithmetic due to over-reliance on digital devices. Students who use calculators or problem-solving apps too often miss critical cognitive processes in calculating and understanding basic concepts. In the long run, this can impact their weak mathematical foundations [18][19].

In addition, not all students have equal access to technology at home and school. This inequality creates a gap in learning achievement between students with personal digital devices and those without. Mistakes in selecting applications or using technology not at the students' cognitive development level can also cause mental fatigue, confusion, and even demotivation in learning. Therefore, the role of teachers is very important in designing thoughtful technology integration according to students' needs and context [20].

3.2.1. Reliance on Technology

Students' dependence on calculators or digital applications in solving fundamental arithmetic problems can hinder the formation of conceptual understanding. Skills such as manual calculation, memorizing mathematical facts, and logical thinking without aids are foundations that must be instilled before using technology as a complement. Students who are not trained in these basic skills tend to feel insecure when solving math problems without the help of a device. This can reduce their cognitive resilience to academic challenges in the long run. Therefore, teachers need to balance technology-based learning with manual and reflective practice.

3.2.2. Focus Disorders in Learning

Technological devices have educational potential but also contain the risk of distraction. Many devices used in the classroom provide access to non-educational applications that can grab students' attention, such as games or social media. Without strict supervision, students can be distracted from learning goals. This phenomenon directly impacts the effectiveness of learning and students' concentration capacity in the long term. For this reason, appropriate supervision and control strategies are needed, both by teachers and parents, to ensure that technology is truly used productively in learning.

3.2.3. Technology Access Gap

The technological access gap is still a major challenge in education, especially in disadvantaged areas or for students from low-income families. While some students enjoy fast internet access and modern devices, others struggle to keep up with digital-based learning. This condition affects academic results and widens the gap in digital skills urgently needed in the information age. Therefore, collaborative efforts between governments, educational institutions, and communities are urgently needed to provide equitable and inclusive digital infrastructure and training.

3.2.4. Decreased Social Interaction

One of the impacts that is no less important than the overuse of technology is the reduction of direct social interaction between students and the surrounding environment. When students are too focused on the device's screen, opportunities to discuss, debate, or collaborate in person become limited. Social skills such as empathy, interpersonal communication, and collaboration are integral to 21st-century competencies. A lack of face-to-face interaction can also negatively impact students' emotional development and mental health. Therefore, it is essential to balance technology use with learning activities based on social interaction.

3.3. Examples of the Application of Technology in Mathematics Learning in Elementary Schools

Along with the rapid development of digital technology, its application in mathematics learning at the elementary school level has also experienced significant progress. One of the most common implementations uses interactive software and applications such as *Photomath*, *Mathletics*, and *Khan Academy* [22]. These programs utilize visual elements, educational games, and practice questions adjusted to the difficulty level to make mathematical concepts more interesting and easier for students to understand. The technology also allows students to learn independently while getting hands-on feedback on the answers they provide, creating an adaptive and responsive learning experience.

In addition to online applications, technologies that support interactivity in the classroom, such as digital whiteboards and interactive projectors, also enrich the mathematics learning process. Teachers can present interactive simulations, dynamic

graphics, and other visual representations to illustrate abstract concepts concretely. For example, fragments or geometric shapes can be visualized in everyday life, thus helping students establish a real connection between the teaching material and reality [23]. Compared to traditional methods such as writing on a regular whiteboard, this approach significantly increases students' appeal and engagement with the material being taught.

Furthermore, technology also plays a vital role in improving students' understanding by presenting instructional films that are visually and narratively designed. Learning videos complemented by animations, illustrations, and engaging audio explanations have proven effective in simplifying complex mathematical concepts [24]. For example, to understand multiplication and division operations, students can watch an animated film that depicts the idea through contextual scenes. Not only does this media make the learning process more enjoyable and engaging, but it also allows for flexible access to learning—both at school and home—without relying on specific times [25]. However, the effectiveness of technology application depends on teachers' readiness to design meaningful learning experiences, not solely on the device's sophistication.

CONCLUSION

Mathematics learning at the elementary school level has undergone a significant transformation and integration in the teaching process. Interactive software, digital boards, projectors, and video-based learning media have allowed students to learn mathematical concepts that were previously considered abstract in a more engaging, visual, and easy-to-understand way. This approach can transform symbolic representations into concrete visualizations, reinforcing students' cognitive processes. In addition, technology provides high flexibility in learning, where students can access learning resources anytime and from anywhere, learn independently, and receive direct feedback on their understanding.

Furthermore, integrating technology into the mathematics classroom not only increases student motivation and engagement but also strengthens conceptual understanding. By presenting math ideas through animations, interactive graphics, and simulations, students more easily build connections between abstract concepts and real-life experiences. This is especially beneficial for elementary school students who often have difficulty understanding arithmetic material, as technology can simplify the learning process and make it more fun and meaningful.

However, to maximize the potential of technology in basic mathematics learning, teachers need to continue to improve their competence in designing effective digital-based learning.

The ability to select, adapt, and integrate digital tools pedagogically is crucial so that technology is complementary and strengthens learning outcomes. On the other hand, institutional support is also indispensable—the availability of stable internet connectivity and adequate technological infrastructure is the main prerequisite for the equitable and sustainable implementation of digital learning. Finally, further research is still needed to explore best practices in using technology in elementary school math learning. This research is essential to ensure that technology is used sporadically and optimized to improve learning outcomes across different skill levels and math topics. An evidence-based approach is

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urgently needed so that digital innovation in education is not only technical, but also pedagogical and humanistic.

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