

## THE ROLE OF TECHNOLOGY IN THE TRANSFORMATION OF MATHEMATICS EDUCATION

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### Abstract

The rapid development of technology has brought significant changes in various fields, including education. Maths education, often considered a challenging subject, can now be transformed by the use of technology to improve students' understanding and learning outcomes. This research uses the literature review method to explore various studies and publications that discuss the role of technology in mathematics education. The results show that technology has a crucial role in the transformation of mathematics education. The use of visualisation software, educational apps and e-learning platforms has been shown to help students better understand abstract mathematical concepts. Technology also enables more adaptive and personalised learning, provides a variety of resources that can be accessed anytime and anywhere, and increases student engagement and motivation. The instant evaluation and feedback provided by technology helps students to immediately correct mistakes and understand the material more deeply. In addition, the integration of technology in mathematics learning also helps to improve students' digital skills, which is important for their future.

**Keywords:** Technology, Transformation, Maths Education.

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## Introduction

The development of information and communication technology (ICT) has brought significant changes in various aspects of life, including education. In this digital era, technology is not only a tool but also a catalyst in the transformation of the education system.

Technology has brought revolutionary changes in the field of education, creating unprecedented opportunities to improve learning and teaching. The use of technology in education encompasses a variety of digital tools and platforms such as computers, tablets, learning applications, educational software, and the internet that enable access to educational resources globally (Sitopu et al., 2024); (Guna et al., 2024). For example, e-learning platforms such as Moodle and Google Classroom facilitate distance and collaborative learning, so students can learn anytime and anywhere. In addition, virtual and augmented reality technologies enable simulation and visualisation of concepts that are difficult to understand through conventional methods, thus enhancing student understanding and engagement (Hairiyanto et al., 2024); (Tubagus et al., 2023); (Aslan & Shiong, 2023).

Furthermore, technology enables personalisation of education, where the content and pace of learning can be tailored to the individual needs of students. This is particularly important as each student has a unique learning style and different abilities (ABRAHAMYAN, 2022). Using learning analytics and artificial intelligence (AI), educators can identify students' strengths and weaknesses in real-time and provide appropriate interventions. In addition, technology also provides an opportunity for teachers to develop innovative and creative teaching methods, increasing student motivation and engagement (Agrawal, 2021). However, while the potential of technology is huge, challenges such as the digital divide, teacher training and infrastructure need to be addressed for the implementation of technology in education to be effective and inclusive. One area of study that has received special attention in the application of technology is mathematics education (Albano et al., 2021).

Mathematics is one of the basic disciplines that has an important role in developing the ability to think logically, analytically, and systematically. However, learning mathematics is often faced with challenges such as lack of student interest, difficulty in understanding abstract concepts, and limitations of conventional teaching methods. In this context, the integration of technology in mathematics education is expected to be a solution to overcome these obstacles (Anuar & Chankseliani, 2021).

Technology offers a variety of tools and platforms that can be used to make learning mathematics more interesting, interactive and easy to understand. For example, the use of learning apps, simulations and maths software allows students to visualise abstract concepts and practice more effectively. In addition, technology

also supports the personalisation of learning, where students can learn at their own pace and learning style (Arthur et al., 2022).

However, although the potential of technology in improving the quality of mathematics education is enormous, its implementation does not always go smoothly. Many factors influence the success of technology integration, such as teacher readiness, technological infrastructure, as well as support from various parties including the government and educational institutions (Arwanto, 2022); (Nurdiana et al., 2023).

Therefore, this study aims to review the existing literature on the role of technology in the transformation of mathematics education. Thus, this research is expected to provide a comprehensive overview of the impact of technology on mathematics learning, the challenges faced, as well as recommendations for more effective implementation in the future.

## **Research Methods**

The study conducted in this research uses the literature research method. Literature research, also known as literature review, is a research method that focuses on collecting and analysing information that has been published in the form of books, journal articles, reports, and other sources. This method is used to gain an in-depth understanding of a particular topic, identify trends, gaps in knowledge, and compile a theoretical basis for further research (Abdussamad, 2022); (Adlini et al., 2022); (Afiyanti, 2008).

## **Results and Discussion**

### **Definition and Theory of Educational Transformation**

Education transformation is a process of fundamental change in the education system that includes reviewing and updating curricula, teaching methods, evaluation, infrastructure, and education policies to meet the evolving needs of the times (Haddar et al., 2023). This transformation aims to improve the accessibility, quality, relevance, and inclusiveness of education so as to produce competent, creative, and adaptive individuals in facing global challenges. Educational transformation does not only mean adopting new technologies, but also creating a learning environment that is more dynamic, participatory, and integrated with scientific and technological developments (Tuhuteru et al., 2023).

Theories of educational transformation have their roots in various disciplines including educational psychology, sociology and change management theory. One widely used theory is Jack Mezirow's Transformational Learning Theory, which emphasises the importance of critical reflection in the learning process (Bankov, 2022). According to Mezirow, transformational learning occurs through experiences that stimulate a person to question and reconstruct their assumptions and

perspectives of the world. In an educational context, this means encouraging students to not only absorb information, but also to critique, analyse and apply knowledge in a broader context (Barbin, 2022).

The implementation of transformation theory in education is realised through various innovative approaches and strategies. The use of technology as a supporting tool for educational transformation, such as e-learning, digital platforms and learning apps, provides an opportunity to create a more flexible and personalised learning environment (Bature et al., 2020). Student-centred teaching methods, such as project-based learning, collaborative learning and flipped classroom, encourage active participation and the development of critical and creative skills. In addition, curriculum renewal that includes cross-disciplinary knowledge, character development, and 21st-century competencies such as digital literacy, critical thinking, and collaboration, are essential elements in a holistic and sustainable transformation of education (Bini et al., 2023).

### **Technology in Education: Concept and Development**

Technology in education refers to the use of digital devices, applications and platforms to support teaching and learning and education management. It includes hardware such as computers, tablets and smartboards, and software including Learning Management Systems (LMS), learning apps and online collaboration tools (Brodie, 2022). The concept of educational technology aims to improve the efficiency, effectiveness and accessibility of education by providing tools and resources that enable more interactive, engaging and individualised teaching and learning methods. Technology also facilitates distance and hybrid learning, allowing access to education without geographical boundaries (Cangiano, 2024).

Technology development in education is an ongoing process that involves innovations in various areas, from software to pedagogy. These developments include the creation of more sophisticated e-learning platforms, accessible mobile learning applications, and AI-based educational evaluation tools that can provide real-time feedback (Chernobilsky, 2021). In addition, education technology is also exploring the use of virtual reality (VR) and augmented reality (AR) to create immersive and immersive learning experiences. The development of these technologies focuses not only on new tools, but also on how they are applied to solve educational problems, increase student participation, and personalise the learning experience (Chwiłkowska-Kubala et al., 2023).

The application of technology in education has had a significant impact on all aspects of the teaching and learning process. Students now have access to educational resources from around the world, can interact with multimedia content, and learn in a way that is more tailored to their learning styles (Costa et al., 2021). Teachers, on the other hand, get better tools to plan, teach and assess student

learning more effectively. Technology also enables more inclusive learning by providing access to educational materials that can be customised for special needs (Drijvers & Sinclair, 2023). These impacts, however, also demand adjustments in teaching standards and training for educators to ensure that they can fully utilise the potential of technology in education. Policy reform and appropriate investment in education technology infrastructure are crucial elements to ensure the sustainability and success of technology in education (Engelbrecht & Borba, 2023).

### **Implementation of Technology in Teaching Mathematics**

The implementation of technology in mathematics teaching has brought about a significant transformation in the way students learn and understand mathematical concepts. Tools such as interactive software, learning apps and educational games provide teachers with the means to introduce mathematical concepts in a more visual and engaging way (Fadiji & Reddy, 2021). For example, digital manipulatives such as GeoGebra allow students to explore geometric concepts through interactive simulations, which can help them understand complex topics in a more intuitive way. This technology also offers flexibility in the learning process, allowing students to learn independently or in small groups according to their own pace (Fauziyatun & Retnawati, 2022).

Technology in mathematics teaching also increases student interaction and participation through more collaborative and participatory teaching methods. Online learning platforms such as Khan Academy provide video tutorials, practice problems, and discussion forums that allow students to learn and practice maths anytime and anywhere (Francisco, 2022). Apps such as Desmos provide online graphical calculators that allow students to create and manipulate mathematical graphs and share the results with classmates and teachers. This interaction not only helps students deepen their understanding of mathematical concepts, but also encourages cooperation and constructive discussion, which is very important in learning mathematics (Freiman, 2020).

One of the great advantages of technology implementation in mathematics teaching is its ability to provide quick and accurate evaluation and feedback. Computer-based evaluation tools such as i-Ready or MAP Growth allow teachers to monitor students' progress in real-time, identify areas of weakness, and customise instruction according to students' individual needs (Goar & Lai, 2020). These technologies can also provide adaptive practice, which adjusts the difficulty of questions based on student performance, thus providing appropriate challenges and supporting continuous learning growth. This immediate feedback is invaluable in the learning process as it helps students to immediately understand their mistakes and correct them, as well as providing teachers with data to plan more effective teaching interventions (Graven & Venkat, 2023).

## **Evaluating the Effectiveness of Technology in Teaching Mathematics**

Evaluating the effectiveness of technology in mathematics teaching requires a comprehensive approach, including both quantitative and qualitative data collection to provide a comprehensive picture. Quantitative data can be obtained through standardised tests, formative tests, and student score results before and after technology implementation. In addition, participation metrics such as frequency of technology tool use, study duration, and task completion rate can provide additional insights (Hasanah & Retnawati, 2022). On the other hand, qualitative data can be obtained through classroom observations, interviews with students and teachers, and satisfaction surveys that explore their perceptions of technology-optimised learning. The combination of these two types of data is important to understand not only academic outcomes but also experiences and attitudes towards technology in learning (Helmane & Vigule, 2022).

One of the key aspects in evaluating the effectiveness of technology in mathematics teaching is its impact on concept understanding. Various studies and reports show that technology-based educational tools can help students understand mathematical concepts better through high visualisation and interactivity. For example, the use of digital manipulative software can help students visualise abstract mathematical operations such as equations or geometric transformations (Hermiati et al., 2021). The use of adaptive applications that adjust the difficulty of questions based on student performance also reinforces basic understanding before moving on to more complex levels. To evaluate this, pre-and-post proficiency tests that focus on specific concepts can be conducted, complete with in-depth analyses of areas that show significant improvement (Hotimah & Lestari, 2023).

The effectiveness of technology in mathematics teaching is not only measured by academic outcomes, but also by student engagement and motivation. Technology has the potential to make learning mathematics more interesting and relevant for students by creating interactive and fun learning experiences. Educational games, maths challenges and other gamification elements can increase students' motivation and desire to learn (Iannone & Thoma, 2023). Direct observation, motivation surveys and student participation in technology-based learning activities can be used to evaluate how much technology contributes to increased engagement. This data provides insight into how technology can change students' attitudes towards mathematics and increase long-term engagement in the subject (Imami, 2023).

While technology offers many benefits, challenges in its implementation also need to be evaluated to get an accurate picture of its effectiveness. These include limited access to technology, uneven infrastructure, and the level of readiness and competence of educators in using technological tools (Jupri et al., 2022). Training and professional development for teachers are key elements in ensuring the

effectiveness of technology in learning. Evaluation of technology effectiveness should include an analysis of the support available to educators, as well as the effectiveness of the training they receive in integrating technology into the curriculum. By evaluating these elements, schools and educational institutions can identify areas for improvement and ensure that the application of technology in mathematics teaching provides maximum benefits for all parties involved (Kandaga et al., 2022).

### **Positive Impact of Technology on Maths Learning**

Technology offers the ability to visualise complex mathematical concepts in ways that were not previously possible. Software such as GeoGebra allows students to manipulate and view graphical representations of functions, equations, and geometric shapes. This helps students to understand abstract concepts more concretely (Khindurangala, 2024). Children can, for example, see how changes in equations affect the shape of the graph directly, which makes concepts such as derivatives and integrals easier to understand. These visualisations provide a more immersive learning experience and make it easier for students to buy into strong mathematical intuition (Kocsis et al., 2022).

Technology enables adaptive learning that is tailored to the needs of individual students. Learning platforms like Khan Academy and maths apps like DreamBox Learning use algorithms to adjust the difficulty of questions and lessons based on students' previous performance. This ensures that each student is challenged according to their ability and helps prevent frustration or loss of interest due to material that is too easy or too difficult. In this way, technology helps to create a more personalised and effective learning experience, which can accelerate the development of individual mathematical understanding (Kristensen et al., 2023).

Technology tools bring an element of interactivity that can cut through the boredom of conventional maths learning. Interactive whiteboards, educational game apps and mathematical simulations allow students to actively participate in the learning process. For example, apps like Mathletics combine games with daily maths practice to encourage students to learn through challenge and competition (Kusdinar & Kismiantini, 2022). Gamification aspects such as virtual rewards and leaderboards not only make learning more fun but also significantly increase student engagement. It develops intrinsic motivation and creates a dynamic and engaging learning environment.

Technology also supports collaborative learning that can be implemented both online and face-to-face. Platforms such as Google Classroom allow teachers to assign tasks that require collaboration between students in solving maths problems. Students can share ideas and work together in developing solutions, which strengthens their communication and cooperation skills (Leung & Donevska-

Todorova, 2021). In addition, the use of online discussion forums or maths-specific chat rooms allows students to ask and answer questions outside of class time, expanding their learning opportunities. This collaboration not only promotes deeper understanding of concepts but also creates a supportive learning community (Liu, 2022).

Technology allows for instant feedback, which is crucial in the learning process. Educational apps and e-learning platforms are often equipped with automatic evaluation features that allow students to know the results of their work immediately after completing an assignment or test (Makramalla & Stylianides, 2024). This instant feedback helps students understand their mistakes immediately and make the necessary improvements without having to wait for the teacher's judgement. Thus, the learning process becomes more efficient, and students can reinforce their understanding before moving on to more complex concepts.

With technology, students have access to various learning resources that are not limited to conventional teaching materials. The internet offers a wide array of educational videos, online tutorials, online courses, articles and e-books that can be accessed anytime and from anywhere. Sites like YouTube provide maths-focused educational channels, such as Numberphile or Khan Academy, where concepts are explained in an engaging and easy-to-understand way. This access allows students to learn at their own pace and seek alternative explanations if they find it difficult to understand material from a particular source (Man-Keung, 2022).

Technology enables the integration of mathematics in the context of everyday life, making concepts more relevant and easy to understand. Augmented reality (AR) and virtual reality (VR) applications allow students to apply mathematical concepts in real-world simulations, such as calculating distances, speeds and angles in architectural designs or games (Manda et al., 2024). Another example is statistics and spreadsheet software used in subjects such as economics and social sciences to process real data. This contextualised learning helps students understand how mathematics is applied in real situations, improves their problem-solving skills and motivates them to learn more (Mkhize, 2022).

In this digital era, mastery of technology is an important skill that every student needs to have. The use of technology in mathematics learning also gives students the opportunity to develop their digital technology skills. Students learn to use various software, applications, and digital tools relevant to their subjects (Muhammad & Adnan, 2023). In addition, they also get used to using the internet wisely to find information and complete assignments. These digital skills are not only beneficial for mathematics learning, but will also be valuable assets for students when they enter the workforce in the future (Ngwabe & Felix, 2020).

## **Conclusion**

Technology plays a crucial role in the transformation of mathematics education, bridging the gap between abstract concepts and students' concrete understanding. With tools such as visualisation software, educational apps and e-learning platforms, technology enables mathematics learning to be more vivid, interactive and relevant to students. The use of graphical visualisations and interactive simulations helps students understand complex concepts more easily, while instant evaluation and feedback allows them to immediately know and correct their mistakes.

In addition, technology provides unlimited access to a variety of learning resources and supplementary materials that can be customised to each student's individual needs and learning style. Websites, online tutorials and educational apps provide multiple ways to explore subject matter, making learning more flexible and personalised. This also increases students' engagement and motivation in learning mathematics, as they can learn at their own pace and in a context that is more relevant to the real world.

More deeply, this transformation also involves improving digital technology skills among students, which is an important asset in today's digital age. With the familiarity they develop in using various technological applications and devices, students not only learn maths but also acquire relevant skills for their future careers. Overall, technology is not only changing the way maths is taught and learnt, but also preparing students to be part of an increasingly technology-driven society.

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