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The Use of Technology in Mathematics Education for Students with Disabilities

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Abstract: Abstract This study discusses the use of technology in teaching mathematics to students with disabilities using the Systematic Literature Review method. The literature sources were taken from the Scispace and Elicit indexes, as well as data from Google Scholar, DOAJ, and Scopus. This study selected publications from 2013 to 2023. The results of the study show that the use of technology in mathematics learning for students with disabilities has had a positive impact in creating an inclusive and supportive learning environment. Technology has helped increase student motivation, reduce learning barriers, and improve the effectiveness of mathematics teaching. This study recommends wider use of technology and further research to understand the impact of technology in mathematics learning for students with disabilities in more detail.

Keywords: Technology, Mathematics teaching, Students with disabilities, Effectiveness, Systematic Literature Review

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A. INTRODUCTION

The use of technology in teaching mathematics to students with disabilities is an innovative and effective approach to support their learning (Rukmana, Supriandi, and Wirawan, 2023). Disabilities can encompass various types, such as visual impairments, hearing impairments, motor impairments, and developmental disorders. Mathematics learning for students with disabilities is crucial in mathematics education due to the specific challenges faced by these students (Andriani, Aksa, and Muhawiyah, 2022). Learning disabilities, difficulties in understanding mathematical concepts, and communication difficulties are among them. Learning disabilities can hinder the process of understanding mathematical material, given that this material often requires complex concepts. Difficulty in understanding mathematical concepts can also impede students' ability to apply these concepts in various contexts, which impacts academic achievement (Marasabessy, 2020). Lastly, communication difficulties can affect students' ability to interact with teachers and classmates, which impacts collaborative learning and better understanding of mathematical concepts. Therefore, it is important for educators to understand these challenges and seek appropriate solutions, including the use of technology, to help improve mathematics learning for students with disabilities.

The importance of studying the use of technology in the context of teaching mathematics to students with disabilities refers to three main aspects: enhancing accessibility, supporting individual needs, and improving motivation and participation (Mumpuniarti et al., 2020). Firstly, the use of technology can enhance the accessibility of mathematics learning materials for students with disabilities. Technologies such as online learning software or specialized applications facilitate access to mathematical materials without being restricted by physical or geographical limitations (Sarnoto et al., 2023). Secondly, technology also supports the individual needs of students with disabilities. Teachers can customize mathematics learning materials according to the specific needs of students, including providing mathematics exercises appropriate to their difficulty level or using specially designed learning aids. Lastly, the use of technology enhances the motivation and participation of students with disabilities in mathematics learning. Technology offers a more interactive, engaging learning experience that supports various learning styles (Jannah, Sari, 2019). This helps improve students' motivation to learn mathematics and increase their participation in learning activities. Therefore, studying the use of technology in teaching mathematics to students with disabilities is crucial for enhancing the quality of their learning experience.

The specific challenges faced by teachers and students in teaching and learning mathematics are multifaceted and require careful consideration. Firstly, the complexity of mathematical concepts often presents difficulties that hinder students' comprehension of the material (Shakespeare, 2017). Secondly, the accessibility of mathematics learning materials becomes a crucial issue. Students with disabilities may encounter difficulties accessing the material due to physical limitations or a lack of supportive technology (Suardana, 2019). Lastly, the inadequacy of suitable learning aids also poses a barrier. Learning aids designed to support mathematics learning for students with disabilities are not widely available, making it challenging for teachers to provide appropriate assistance (Ningsih, Studi, and Guru, 2019). In addressing these challenges, teachers need to develop effective teaching strategies and techniques to assist students with disabilities in understanding mathematical concepts, improving the accessibility of learning materials, and providing suitable aids to support their learning (Sutisna, Adiwisastra, and Warnilah 2020).

In the field of education, technology has been widely applied to support the learning process of mathematics for students with disabilities (Ainu Ningrum, 2022). Several examples of technology usage in supporting mathematics learning include the development of specialized applications, hardware devices, and computer programs. With the assistance of technology, computer-based instruction and software have been extensively utilized to aid students in understanding mathematical concepts (Shin et al. 2023). Gaming technology has also been employed as a means to make mathematics learning more engaging and accessible to students with special needs. Furthermore, assistive technologies such as non-visual display formats and tactile content have facilitated visually impaired students' access to mathematical symbols and expressions equitably (Adeilton et al. n.d.). With the presence of digital and assistive technologies, there has been a significant improvement in the motivation, attitudes, and academic performance of students in mathematics and science subjects (Oyebanji and Oyebanji 2023). These findings underscore the importance of integrating technology into

mathematics learning, as it can enhance the learning experience and outcomes for students with disabilities.

Damayanti and Nuzuli (2023) assert that technology in the process of mathematics learning offers various advantages, including enhanced conceptual understanding, higher student engagement, and broader accessibility. Supianti (2018) argues that digital tools such as computer software, websites, and online tutorials enable students to easily access information, expedite the learning process, and apply mathematical concepts. Lestari and Kurnia (2023) state that technology also provides a variety of tools and resources that can be utilized by teachers in their instruction. This fosters innovation and the development of new teaching practices. However, there are several challenges that may be encountered, such as a lack of teacher training in effectively utilizing technology and the need for specialized devices. Therefore, it is crucial to address these challenges to fully leverage technology in mathematics learning.

Previous research has examined various aspects of mathematics education for students with disabilities. It was found that elementary school students generally have a neutral attitude towards mathematics, likely influenced by the learning difficulties they face (Besse Intan Permatasari 2020). Highlighting the moderate mathematical connection abilities of students at the junior high school level, indicating the potential challenges in understanding mathematical concepts. Proposing the use of ethnomathematics, which explores cultural aspects within mathematics, as a more engaging approach to teaching mathematics (Fitriani 2022). Finally, emphasizing the importance of discipline in learning, especially for students with disabilities, and the need for direct approaches, corrective actions, and consequences for rule violations (Sendayu, Masrul, and Kusuma, 2020). These studies collectively underscore the need for innovative and engaging teaching methods, as well as the importance of discipline and support for students with disabilities in mathematics education.

The research findings indicate a gap between the understanding of mathematical concepts among students with disabilities and the use of technology to support their mathematics learning. Although the importance of technology in enhancing accessibility, supporting individual needs, and increasing motivation and participation of students with disabilities in mathematics learning has been acknowledged, challenges remain in addressing this gap. Some challenges faced include the complexity of mathematical concepts, accessibility of learning materials, and a lack of suitable assistive tools. Therefore, there is a need for further research to identify and address these gaps, as well as to develop effective teaching strategies and techniques in utilizing technology for mathematics learning among students with disabilities. Through this research, it is hoped that the challenges in integrating technology into mathematics learning for students with disabilities can be identified, and effective solutions can be found.

B. METHOD

This study aims to compile an article on the Application of Technology in Mathematics Teaching for Students with Disabilities using a Systematic Literature Review approach. In this research, our objective is to provide clear and detailed information on how technology is utilized in mathematics teaching for students with disabilities, as well as to evaluate the effectiveness and success of implementing such technology. This research is expected to make a significant contribution to our understanding of how technology can enhance the learning experience in mathematics for students with disabilities, and support the development of more inclusive and effective teaching approaches and strategies. Therefore, the outcomes of this study are anticipated to help improve the quality of mathematics education for students with disabilities, and strengthen the theoretical and practical foundations for educators and researchers in this field.

The literature search for this research was conducted through several relevant databases, such as Google Scholar, Elicit, Scispace, and Scopus. Keywords used in the search included "technology", "mathematics teaching", "students with disabilities", and "effectiveness". The search was performed for the period from 2013 to 2023 to ensure that the literature used was the most relevant and current. In this search, we reviewed articles published in scholarly journals, conferences, and related publications. We also considered books, reports, and other relevant sources of information on the research topic. By employing this approach, we aim to gather the most up-to-date and reliable data and information to support the drafting of this article.

In determining the inclusion and exclusion criteria, we adopted a systematic and careful approach. We ensured that the articles used in this research met high standards of quality and relevance. The inclusion criteria we employed were: firstly, articles must emphasize the application of technology in mathematics teaching; secondly, articles must discuss the application of technology specifically for students with disabilities; and thirdly, articles must outline the effectiveness and outcomes of the application of such technology. Meanwhile, the exclusion criteria we applied were: firstly, articles that were irrelevant to the research topic; secondly, articles lacking relevant data or information; and thirdly, articles published before 2013 or after 2023. By employing this approach, we aim to ensure that the articles used in this research are of high-quality and relevance, thereby making a significant contribution to our understanding of the application of technology in mathematics teaching for students with disabilities.

Article selection was carried out in stages in this research. In the first stage, we reviewed the titles and abstracts of articles obtained from the literature search. This review was conducted to ensure the relevance of the articles to our research topic. In the second stage, articles deemed relevant were downloaded and thoroughly read. We evaluated the quality and accuracy of the information presented in these articles. Articles that met the predetermined inclusion criteria were extracted and used as sources of information in our article drafting process. By employing this approach, we aim to ensure that the articles used in this research are of high quality and relevance, thereby making a significant contribution to

our understanding of the application of technology in mathematics teaching for students with disabilities.

C. RESULTS AND DISCUSSION

1. Types of Technology Utilized in Mathematics Teaching for Students with Disabilities According to Literature

According to the literature reviewed, there are several types of technology commonly used in teaching mathematics to students with disabilities. These types include computer-assisted instruction, Assistive Technology (AT), and gaming technology. Computer-assisted instruction, such as software and calculators, has been popular since the 1980s and 1990s (Shin et al., 2023). AT, specifically designed to support students with visual impairments (VI), has proven effective in engaging VI students in mathematics learning, focusing on non-visual display formats and accessibility (Ketema Dabi and Negassa Golga 2023). Additionally, the use of gaming technology, offering innovative and interactive approaches, has been shown to develop thinking and creative abilities in learners with special needs (Boriak 2023). These technologies aim to provide equitable access, enhance engagement, and improve academic performance for students with disabilities in mathematics learning (Iyamuremye et al. 2023).

Sari, Sugiyanti, and Pramasdyahsari, (2021) asserted that a variety of technologies have been applied in teaching mathematics to students with disabilities, focusing on enhancing their mathematical literacy. n.d., (2021) in their work, and Rodliyah, Rodliyah, Wijayanti, and Basir, (2023) alike highlighted the importance of instructional materials that support the development of mathematical literacy, particularly in terms of utilizing various sources of information and communication interpretation. Kristin n.d., (2021) dan Maryam n.d., (2023) explored the use of specific types of mathematical problems and the impact of students' learning independence on their mathematical literacy, respectively. These studies collectively affirm the importance of technology in providing tailored support for students with disabilities in their mathematics education.

The utilization of various types of technology in teaching mathematics to students with disabilities reflects efforts to provide more inclusive and effective access to learning. Computer-assisted instruction offers flexibility in delivering content and employs aids to facilitate comprehension. Assistive technology, particularly focused on students with visual impairments, opens up broader participation opportunities for VI students in mathematics learning. Meanwhile, the use of gaming technology provides a more interactive and engaging approach for students with special needs, thereby enhancing their motivation and interest in learning. Although these technologies offer significant potential in improving mathematics education for students with disabilities, there are several challenges that need to be addressed. For instance, the use of technology needs to be tailored to the needs and characteristics of individual students, and it must be ensured that the technology genuinely supports effective mathematics learning.

2. Utilizing Technology to Enhance Student Understanding

Research findings indicate that the utilization of technology in the field of education significantly enhances students' learning achievement and understanding of mathematical concepts (Rizada and Rey, 2023). Studies conducted on millennial students show that the use of technology in teaching, such as technology-based instructional methods, leads to improved academic performance in mathematics compared to conventional teaching approaches (Suyuti et al., 2023). Furthermore, research also finds that the use of interactive mathematics software positively impacts conceptual understanding and performance of elementary school students dasar (Uwineza, Uworwabayeho, and Yokoyama, 2023). Integrated technology has also been proven to enhance students' logical thinking abilities at the elementary education level in the context of mathematics (Davidi, Sennen, and Supardi, 2021). However, it should be noted that the use of digital modules alone may not suffice to improve students' relational understanding of mathematical concepts (Mas'ud and M, 2022). Overall, research asserts that technology can serve as an effective tool in enhancing students' understanding of mathematical concepts, but careful selection and proper integration into the learning process are necessary to achieve optimal outcomes.

Several studies have explored the use of technology to enhance students' understanding. Yulianawati, Novia, and Suyana, (2016) applied a metacognitive approach to improve problem-solving abilities among high school students in physics, while Tumiyem, n.d., (2021) found that contextual information services and learning can positively influence students' career planning. Arimbi, n.d., (2023) developed integrative thematic comic books to enhance creativity and collaboration among fourth-grade students, and Asnimar, (2019) focused on improving English speaking skills among eighth-grade students. Collectively, these studies suggest that technology can be effectively utilized to enhance students' understanding across various subjects.

Research indicates that leveraging technology in mathematics education can yield significant benefits for students, particularly in enhancing their understanding of mathematical concepts. By harnessing technology, students can actively engage in learning, enabling them to grasp the material more effectively. Additionally, the use of technology can create a more engaging and interactive learning environment, which can boost students' motivation to learn. Although studies show positive outcomes regarding the effectiveness of using technology to enhance students' understanding of mathematical concepts, it is important to note that relying solely on digital modules may not suffice to improve students' relational understanding of mathematical concepts. Therefore, a more holistic and integrated approach to the use of technology in the learning process is needed.

3. The Effectiveness of Technology Use among Different Types of Disabilities

The use of technology in the context of disabilities has been found to have varied effectiveness, depending on the type of disability present. One study identified significant differences in the impact of technology use among different types of technologies and work contexts (Damianidou et al., 2018). Another research evaluated technology-supported interventions to enhance ambulation in individuals with severe to profound intellectual disabilities, along with visual or motor impairments, and found that the interventions

successfully increased step-response frequency (Lancioni et al., 2021). Suggestions have been made to utilize assistive technology as a solution to meet the physical needs of individuals with disabilities while also enhancing their quality of life, while reducing costs for service providers layanan (Aslanzadeh and Keating, 2016). Additionally, eye-tracking technology has been developed to aid individuals with disabilities in performing tasks without using hands (Arifin and Widyastono, 2020). Finally, a project aimed at improving communication with individuals with severe intellectual disabilities through mobile applications and multimodal resources has shown promising results in enhancing professional skills and self-confidence (Pinazo, 2017).

The effectiveness of technology usage varies among different types of disabilities. Raharjo, Sulaeman, and Sriyani (2018) and Mingkid, Liando, and Lengkong, (2017) both emphasize the importance of effective resource management in rural development but do not specifically address the use of technology by people with disabilities. Raharjo, Sulaeman, and Sriyani, (2018) discuss the potential misuse of village funds but do not delve into the utilization of technology by individuals with disabilities. Aira n.d., (2022) discusses the positive impact of computerized systems on employee performance but does not focus on the specific needs of people with disabilities. Therefore, while these studies provide valuable insights into resource management and technology usage in various contexts, they do not directly address the effectiveness of technology usage among different types of disabilities.

The research findings indicate that the effectiveness of technology varies depending on the type of disability present. Studies demonstrate that technology can be tailored to the specific needs of individuals with disabilities, such as improving ambulation, assisting with daily tasks, and enhancing communication skills. This underscores the importance of developing technology that can be customized to the needs of individuals with disabilities. Although these studies show promising results in the use of technology for various types of disabilities, it should be noted that further research is needed to explore differences in technology effectiveness for different types of disabilities. Additionally, other aspects such as accessibility, cost, and support required to implement such technology should also be considered.

4. Utilization of Technology to Facilitate Student Inclusion

Technology has become a crucial tool in facilitating the inclusion of students with disabilities in mathematics education at schools. Inclusive mathematics education presents new challenges for both students and teachers. As a potential solution, the use of educational gaming technology has been considered in teaching mathematics to students with special needs (Omarova and Maratkyzy, 2023). Assistive technology (AT) has also proven effective in providing support to students with visual impairments (VI) in the mathematics learning process (Ketema Dabi and Negassa Golga, 2023). This AT not only ensures fair access but also addresses potential accessibility (Licwinko, 2023). Additionally, a variety of technologies, such as mainstream educational technology and accessible digital resources, can be utilized to support all students in inclusive classroom environments, creating a more inclusive learning environment (Karagianni and Drigas, 2023). The concept of "e-inclusion" pedagogy

emphasizes the use of technology in educational activities to meet the individual needs of students with special educational needs, aiming to enhance their active participation and acquire academic and functional life skills. The integration of technology in mathematics education has been shown to have a positive impact, even in resource-limited environments. Therefore, ensuring smooth access to technological resources is key to the successful implementation of technology in mathematics education, especially in inclusive environments (Maqoqa, 2023).

The use of technology to support student inclusion is a complex approach, as evidenced by several studies. Muslih n.d., (2021) emphasizes the importance of early reading skills and the use of syllabic methods to address reading difficulties. Djunaidi, (2021) highlights the role of vocabulary development and the use of dictionaries in reading comprehension. Pratiwi n.d., (2018) asserts the importance of leadership development in students, which can be facilitated through technology-based leadership programs. Iskandar Agung n.d., (2017) Tdiscusses the development of patriotism among students, which can be supported through technology-based educational initiatives. These studies collectively underscore the potential of technology in addressing various aspects of student inclusion.

The findings of these studies indicate that technology plays a significant role in facilitating the inclusion of students with disabilities in mathematics education within school environments. The utilization of various types of technology, such as gaming technology, assistive technology, and digital resources, has proven effective in supporting the learning process and enhancing the participation of students with disabilities in mathematics education. The integration of technology within the context of inclusive education also enables the creation of learning environments that are more accommodating and responsive to the individual needs of students. While the research results demonstrate the effectiveness of technology in facilitating the inclusion of students with disabilities, it is important to note that the use of technology must be judicious and tailored to the needs of the students. Moreover, the availability of resources and training for teachers also plays a crucial role in the successful implementation of technology in inclusive mathematics education. Evaluation of the long-term impact of technology use in mathematics education for students with disabilities is also an important consideration.

5. Barriers or obstacles identified in the implementation of technology in teaching mathematics for students with disabilities.

Several barriers identified in the implementation of technology in teaching mathematics for students with disabilities are as follows: 1) Lack of accessibility and compatibility of remote technology for visually impaired students, such as difficulties in editing graphics or using different tools and techniques (Omarova and Maratkyzy, 2023), 2) Limited access to devices, internet, software, and digital literacy skills for special education students, resulting in inequity in technology-supported learning opportunities (Mikulowski, 2022), 3) Challenges in delivering accessible technology-based instruction due to structural factors, such as resource allocation, digital literacy training for students, teacher training, technology-related decision-making, SPED job roles, and home-school communication (Naibaho, 2020), 4) Environmental factors, such as disruptions and lack of technical knowledge among parents and teachers,

affecting the use of assistive technology strategies in mathematics learning (Esquivel et al., 2022), 5) Constraints on the use of teaching aids and the lack of engaging teaching approaches and methods in implementing and facilitating mathematics learning for students with special educational needs (Azmi and Tahar, 2023).

The application of technology in teaching mathematics to students with disabilities faces several challenges. Prayitno and Masduki, (2017) identified these challenges, which include the perception that mathematics is a difficult subject, Soni, (2021) highlighted the impact of environmental factors on the performance of individuals with disabilities, Absari and Nurdian, (2022) emphasized the need for guidance and support in adapting to new learning habits, especially during the COVID-19 pandemic. Prayitno and Masduki, (2017) Despite encountering these challenges, the importance of understanding mathematics in daily life remains emphasized.

Moreover, challenges in providing accessible technology-based instruction also pose a problem. Structural factors such as resource allocation, digital literacy training for students, teacher training, technology-related decision-making, and the role of Special Education (SPED) professionals all play a role in determining the effectiveness of technology use in mathematics learning for students with disabilities. The lack of communication between home and school also presents a constraint, as students may not receive sufficient support at home to utilize technology in mathematics learning. Environmental factors also play a significant role in hindering the implementation of technology in mathematics learning for students with disabilities. Disturbances and a lack of technical knowledge among parents and teachers can hinder the use of assistive technology strategies in mathematics learning. Finally, limitations in the use of teaching aids and a lack of engaging teaching approaches and methods also pose challenges in the implementation and facilitation of mathematics learning for students with special educational needs.

D. CONCLUSIONS AND SUGGESTIONS

Based on the evaluation of research findings, it can be concluded that the use of technology in mathematics learning for students with disabilities has brought about positive impacts in creating inclusive and supportive learning environments. However, there are still some gaps that need further attention. First, there remains variation in the effectiveness of technology use depending on the type of disability an individual has. This underscores the need for further research focusing on the development of more specific and tailored technologies to meet the diverse needs of students with disabilities. Second, there are still obstacles in the implementation of technology, such as lack of accessibility and compatibility, as well as structural and environmental challenges. Therefore, urgent research topics to be explored in the future include the development of more inclusive and specific technologies, as well as research identifying strategies to overcome these barriers. These research topics need to focus on efforts to improve accessibility, training, support, and evaluation of technology in mathematics learning for students with disabilities. Thus, a more inclusive and supportive learning environment for all students, without exception, can be created.

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