



ARTIFICIAL INTELLIGENCE IN MATHEMATICS EDUCATION OF STUDENTS WITH SPECIAL EDUCATIONAL NEEDS

Mary-Jane Lessing, Ugorji Iheanachor Ogbonnaya

University of Pretoria, South Africa

E-mail: u22822977@tuks.co.za, ugorji.ogbonnaya@up.ac.za

Abstract

This study examined the role of artificial intelligence (AI) in supporting the mathematics education of students with special educational needs (SEN). Thirty peer-reviewed articles were analysed to examine (i) the types of AI technologies implemented in mathematics education, (ii) evidence on the effectiveness of AI interventions in improving learning, (iii) the benefits and limitations of AI in special education, (iv) comparisons of AI applications with traditional methods in terms of personalisation, engagement, and accessibility, and (v) applications of AI in supporting specific disabilities. The findings indicated that intelligent games, chatbots, personalised learning systems, and intelligent tutoring systems were the most frequently utilised AI-powered tools. All studies assessing effectiveness reported positive impacts on mathematical achievement, as well as benefits such as reduced mathematics anxiety, increased motivation, and enhanced independence among learners. Reported challenges included high costs, ethical concerns, teacher preparedness, and a digital divide limiting equitable access. Compared to traditional methods, AI offers more accurate diagnosis of learning difficulties, greater opportunities for personalised learning, and increased accessibility. AI showed promise in addressing specific disabilities such as dyscalculia and autism through adaptive and diagnostic tools. The review concluded that AI should be viewed as a complementary tool that extends teachers' capacity to individualise mathematics instruction for students with SEN.

Keywords: artificial intelligence, conceptual knowledge, mathematics, special education, special needs, disabilities, learning disabilities

Introduction

Over the past decade, accelerated technological advancements have transformed various sectors of society, including education. Among these developments, Artificial Intelligence (AI) has emerged as a primary driver of educational innovation. Clark et al. (2025) argue that AI has fundamentally reshaped how teaching and learning are conceptualised, delivered, and experienced. Although AI has been an active research area for over fifty years, recent technological progress has significantly expanded its applications in education, and scholars predict that it will remain a central research focus for years to come. The continued academic interest in AI underscores its importance in shaping future learning environments (Chattopadhyay, 2024). Within the educational context, AI is increasingly recognised as a tool that promotes personalisation, efficiency, inclusivity, and innovation, while simultaneously raising ethical and equity concerns and redefining the role of teachers.

Artificial Intelligence can be defined as “the study and development of intelligent agents that can perceive their environment and take action to increase their chances of success” (Chattopadhyay, 2024, p. 206). These systems, programmed with extensive linguistic and behavioural databases, are capable of analysing interactions and generating contextually appropriate responses (Gill et al., 2024). Their ability to mimic human-like communication and reasoning has made them particularly valuable in educational settings. Beyond general education, AI's potential to support students with special educational needs (SEN) in

mathematics classrooms has gained increasing attention. Researchers argue that AI systems can create interactive, adaptive, and inclusive learning environments that meet the diverse needs of all learners (Chattopadhyay, 2024).

Mathematics is a core subject that often presents unique challenges for students with SEN due to its reliance on abstract reasoning, visual processing, and the use of specialised mathematical language. Achieving mathematical success typically requires strong attention, memory, problem-solving, and linguistic comprehension skills (Bhushan et al., 2024). Students with SEN may experience difficulties in one or more of these areas, limiting their ability to engage with mathematical concepts fully. Mathematics literacy, which encompasses “numbers, fractions, four operations, geometrical shapes, problem-solving, and measurement for students to solve daily problems” (Kramarenko et al., 2021, p. 1), is fundamental for daily functioning and academic progress. The effective development of mathematics literacy depends mainly on the teaching methods and learning environments provided (Fritz et al., 2019). When instruction is adapted to accommodate learners with diverse needs, students with SEN can develop meaningful mathematical understanding (Kramarenko et al., 2021). However, empirical evidence consistently indicates that these students often perform significantly below their peers in mathematics (Bakker et al., 2024). Current tools used in special mathematics education, such as talking calculators, foam numbers, fraction pie stamps, large dominoes, and geo-boards (Vincent, 2024), primarily offer tactile or auditory support. In contrast, AI-powered solutions such as intelligent tutoring systems, adaptive learning platforms, and augmented reality applications provide dynamic, personalised, and data-driven interventions. A study by Lazo-Amado et al. (2022) demonstrated the effectiveness of an augmented reality mobile prototype designed for students with SEN, with students, parents, and teachers all endorsing its adoption for special education purposes. These findings highlight growing acceptance of and demand for technology-based learning interventions.

Recent technological innovations, particularly AI-based systems, present promising opportunities to address the challenges faced by students with SEN. Computer-assisted instruction, for example, can analyse students’ responses and tailor support to individual needs (Dhingra et al., 2024). Given that approximately one in six students in the United States is diagnosed with special educational needs (Centers for Disease Control, 2019), a trend likely reflected in other countries, and that many teachers lack the knowledge, confidence, and emotional preparedness to implement inclusive pedagogies effectively (Kramarenko et al., 2021), the integration of AI tools into mathematics education is both timely and essential. Leveraging AI’s adaptive and diagnostic capabilities can enhance accessibility, engagement, and learning outcomes for students with SEN, thereby promoting greater educational equity and inclusion.

Despite the rapid advancement and growing integration of Artificial Intelligence (AI) technologies in education, their effective utilisation to support the mathematics learning of students with special educational needs (SEN) remains limited and uneven. While AI has demonstrated potential to personalise instruction, enhance engagement, and provide adaptive feedback, there is insufficient empirical understanding of how these technologies are applied specifically to address mathematical learning challenges among students with diverse disabilities such as dyscalculia, dyslexia, autism spectrum disorder (ASD), and attention deficit hyperactivity disorder (ADHD). Traditional teaching methods often fail to adequately accommodate the individual cognitive, behavioural, and emotional profiles of students with SEN, resulting in persistent difficulties in mathematical understanding and achievement. At the same time, teachers often lack the training, resources, and technological readiness necessary to effectively integrate AI-based tools into special education contexts. Furthermore, ethical concerns, high implementation costs, and digital inequities persist as barriers to the widespread and equitable use of AI in inclusive mathematics education.

Although existing research highlights the general benefits of AI, such as improved motivation, reduced anxiety, and enhanced independence among learners, there is a lack of consolidated evidence on the specific types of AI technologies used, their pedagogical effectiveness compared to traditional approaches, and their capacity to address the unique learning barriers faced by students with different disabilities.

Therefore, the problem of this study is the limited systematic understanding of the role, effectiveness, and challenges of using artificial intelligence technologies to support mathematics education for students with special educational needs. This knowledge gap constrains educators' and policymakers' ability to make informed decisions on adopting and integrating AI-driven solutions to promote equitable and personalised mathematics learning experiences for all learners, especially SEN learners.

Research Aim and Research Questions

Despite the growing interest in both special education and the incorporation of AI in education, a gap in the literature still exists regarding how AI systems are integrated into the mathematics education of students with SEN. Much of the existing literature focuses on AI incorporation in general education, providing limited insight into how AI systems have been utilised to accommodate SEN students in the mathematics classroom. This systematic literature review addressed this gap by providing insight into the benefits, limitations, and effectiveness of AI applications in mathematics education for SEN students, intending to inform both future research and practical incorporation. Guided by the aim, this study was structured around the following research questions: (i) What types of AI technologies have been implemented in the mathematics education of SEN students?, (ii) What evidence exists on the effectiveness of AI-powered interventions in improving learning outcomes for SEN students?, (iii) What are the reported benefits and limitations of using AI-powered systems in special education?, (iv) How do AI applications in special education compare to conventional methods in terms of personalisation, engagement and accessibility?, and (v) How can AI be used to support SEN students?

Research Methodology

A systematic literature review is a comprehensive synthesis of current literature, designed to evaluate the body of knowledge on a specific topic in a transparent and reproducible manner (Lame, 2019). The review followed the PRISMA guideline; Identification, Screening, Eligibility, and Inclusion (bin Mohamed et al., 2022) to identify, collect, and analyse the publications. The PRISMA guideline was chosen as the framework for this systematic literature review due to its success in guiding such reviews. The PRISMA guideline enables authors to conduct a systematic literature review effectively (Nazir & Das, 2025).

Identification

The first step in the PRISMA guideline is to identify the publications by filtering through selected databases and journals. The review utilised Google Scholar, Scopus, ProQuest, and ERIC to identify publications related to this review. Google Scholar includes publications of all the database journals, thus providing a broader search, while Scopus, ProQuest, and ERIC are education-focused journals that ensure the search of education-specific publications. The review initiated the search for publications utilising pre-selected keywords.

Keywords utilised to search the journals included Artificial Intelligence, mathematics, and special education. To ensure that all publications on the databases were identified, the study included a list of synonyms during the identification process. The list of synonyms is presented in Table 1.

Table 1
List of Synonyms of The Predetermined Keywords

Mathematics	Education	Artificial Intelligence	Special education
Math	Teaching	AI	Inclusive education
Maths	Learning	Intellectual technologies	Students with disabilities
Mathematical	Instruction	Machine learning	Special needs education
			Gifted students

Utilising the keywords and their synonyms, the review identified a total of 82,600 publications. After examining the titles and keywords within the publications, it was found that 65,248 publications did not include all of the keywords provided in the search. These studies were excluded in the subsequent stage of the screening process. Therefore, a total of 17,352 publications were subject to the screening process.

Screening

To ensure that the identified publications met the study's scope, predetermined inclusion and exclusion criteria were established. Table 2 displays the review's inclusion and exclusion criteria.

Table 2
Inclusion and Exclusion Criteria

Inclusion	Exclusion
Publications between 2015 and 2025 (August)	<2015
Peer reviewed	Non-Peer reviewed
Full text	Summaries
Language: English	Non-English
Mathematics	Other educational subjects not related to mathematics.
Education	General publications not related to education.
Special education	Educational publications not related to special education.
Original study	Review

The remaining 17,352 publications were included in the screening process. The screening process involved analysing the publications' titles and abstracts to determine if they met the inclusion requirements. A significant number of publications were excluded from the study because they focused on education in general and did not specifically address the mathematics education of SEN students. Following the screening process, 568 publications were identified for further analysis in the eligibility phase of the review.

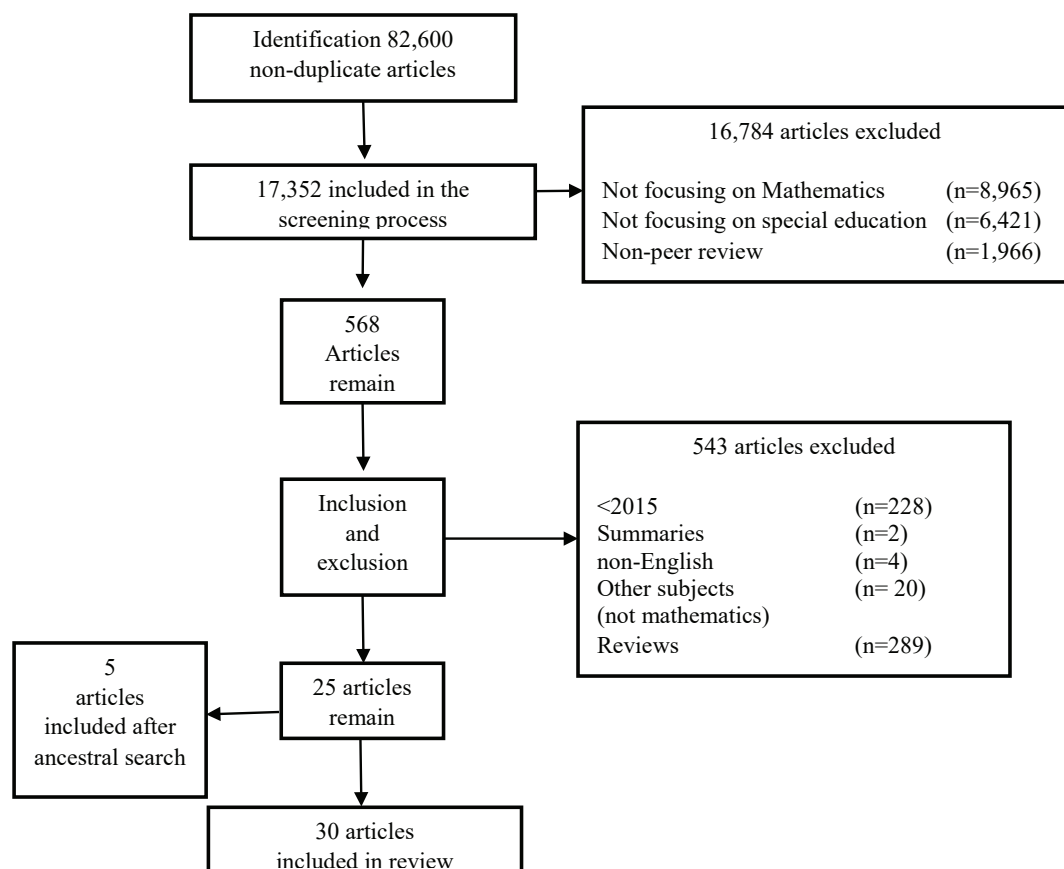
Eligibility

The titles, abstracts, methods, and conclusions of the remaining 568 papers were examined to facilitate further analysis. A total of 25 papers were selected for review out of the 568 publications. Publications performed before 2015 and those that did not focus on mathematics education were the most significant exclusion criteria, resulting in the removal of the majority of publications.

Inclusion

The remaining 25 papers underwent an ancestor analysis, where references were examined to identify publications that met the review's inclusion criteria, ensuring that no publications were overlooked. A total of 30 papers were included in the review after an additional five publications were included. The PRISMA diagram in Figure 1 provides a comprehensive summary of the papers included in the review.

Figure 1
PRISMA Diagram of the Inclusion and Exclusion Process



Data Analysis

A thematic analysis was conducted to synthesise findings from the 30 publications. An inductive approach was employed, allowing themes to emerge directly from the data without

imposing prior assumptions. Each publication was read multiple times, and relevant findings were highlighted and coded. The codes were then grouped into broader categories that reflected recurring patterns across the studies. To ensure reliability, codes and themes were discussed among the research team, and discrepancies were resolved through a consensus-based approach. The final themes were validated against the original publications to ensure they accurately represented the findings.

The themes of the review included the impact of AI on students' conceptual understanding of mathematics, the benefits and challenges of using AI for adaptive learning in mathematics classrooms, and how mathematics teachers perceive and adopt AI tools in their classrooms.

Methodological Quality and Risk of Bias

To ensure the rigour and reliability of this systematic literature review, several measures were taken throughout the selection and evaluation process. Both authors independently screened the titles and abstracts of the studies identified in the databases, applying the pre-established inclusion and exclusion criteria consistently. Any disagreements were discussed until consensus was reached, which helped minimise the risk of overlooking relevant studies and strengthened the validity of the final set of included publications.

A pilot review was first conducted to confirm that all relevant coding categories were captured in the review form. Following this, the primary coding process was carried out collaboratively. Each author independently applied the inclusion and exclusion criteria and coded the studies, after which decisions were cross-checked. Discrepancies were resolved through discussion, providing a form of inter-rater reliability and ensuring consistency in coding.

To further ensure methodological quality, a risk of bias assessment was conducted for each included study. Potential sources of bias were identified, and the authors revisited and discussed the studies, ultimately reaching a consensus on the final evaluations. These steps collectively enhanced the transparency, trustworthiness, and overall quality of the review, reducing subjectivity and supporting the robustness of the findings.

Research Results

The systematic literature review identified and analysed 30 publications that explored the use of Artificial Intelligence in the mathematics education of SEN students. The results are presented in five main sections: (1) the types of AI applications reported in the literature, (2) their effectiveness in improving learning outcomes, (3) the benefits and limitations identified by educators, students, and parents, (4) comparisons with conventional teaching methods, and (5) how AI has been applied to support learners with SEN. The following subsections provide a detailed synthesis of these results.

Types of AI technologies implemented in special education settings over the past two decades

A total of 30 publications were included in the review, 2 of which focused on types of AI-powered systems utilised in special mathematics education. The titles of the 22 articles (1, 2, 3, 4, 6, 7, 8, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 23, 24, 25, 27, 29) are shown in Appendix A. The findings of the 22 publications were further analysed to examine the types of AI applications identified.

Table 3

The findings on the Types of AI Applications Used in Mathematics Education for SEN students.

Types of AI applications	Number of publications
Chatbots	7
Intelligent games	11
Intelligent tutoring systems	6
Personalised learning systems	5
Communication aids	1
Intelligent robots	2
Virtual reality	2
Classroom simulation tools	1
Virtual instructional coaches	1

It is important to note that some publications reported more than one AI-powered system; therefore, the total number of publications in Table 3 may not accurately reflect the total number of studies reviewed. Intelligent games (11 publications) account for the highest number of publications, suggesting game-based interventions are a popular AI-powered system incorporated in special education. Chatbots (7 publications) are also well incorporated in special education, reflecting their growing role in providing real-time support and simulating human interaction. Personalised learning systems (5 publications) and intelligent tutoring systems (6 publications) seem to be in the mid-range of publications, indicating an interest in these applications' ability to individualise and support mathematics education. On the other hand, intelligent robots (2 publications) and virtual reality (2 publications) are less frequently implemented; this can be attributed to the high cost of these systems. The least implemented AI systems are communication aids (1 publication), classroom simulation tools (1 publication), and virtual instructional coaches (1 publication).

AI-powered tutoring and personalised platforms have been utilised to address the diverse needs of SEN students, providing individualised tutoring that would have otherwise been omitted due to time constraints in education. AI-powered applications, such as ALEKS and Carnegie Learning, are beneficial in generating intellectual tutoring and personalised learning interventions for students with SEN (Almulla & Amjad, 2025). In a similar study, Vincent (2024) developed an AI application that utilises a diagnostic questionnaire to identify students' individual needs and challenges, and then develops mathematical support tailored to each student's difficulties. Adaptive learning is also evident in the number sense game developed by Orefice (2022), which continuously adapts in difficulty as the AI system analyses the students' responses.

Beyond these targeted tools, several AI-powered applications are currently incorporated in mathematics education for SEN students. Current AI systems utilised in education are "chatbots, intelligent tutors, personalised learning systems, educational data analytics, virtual reality platforms, game-based applications, classroom simulation tools, and virtual instructional coaches" (Clark et al., 2025, p. 2). Among these, ChatGPT has received significant attention over the last two years. However, while these applications offer significant benefits for the education of SEN students, Rizos et al. (2024) found that the majority of teachers lack adequate knowledge of the application to promote its effective incorporation.

Due to the benefits of several technological innovations, AI-powered systems have been combined with other tools to present AI-generated instructions. AI-powered robots, for

example, have received increasing interest due to the advancements in AI systems. Al Omoush and Mehigan (2023) argued that robots can be utilised to present unique teaching methods and personalised lessons, while providing a form of interaction due to the robot's physical embodiment in the classroom. Furthermore, AI-powered systems are frequently combined with virtual realities (VR) or augmented realities (AR), as AI is utilised to create instructional materials and worksheets. At the same time, AR presents the lesson utilising a teaching method tailored to the special needs of individual students (Al Omoush & Mehigan, 2023).

Collectively, these applications offer distinct opportunities for personalised learning, accessibility, and engagement. These efforts contribute to meeting students' diverse needs and enhancing opportunities to learn mathematics, especially for those with SEN.

*The effectiveness of AI-based interventions in improving
learning outcomes for SEN students*

Within the body of publications reviewed, nine publications (2, 8, 12, 13, 15, 16, 19, 23, 29) addressed the effectiveness of AI-powered systems in improving learning outcomes for SEN students (see Appendix A). Collectively, the findings of the studies suggest that incorporating AI in special education has a positive effect on mathematical achievement.

For instance, Bakker et al. (2016) studied the effects of intelligent computer games on 81 SEN students' mathematical abilities. They found that intelligent, computerised mathematical games significantly improved the overall mathematical abilities of SEN students. Similarly, Blangiardi (2023) developed an intelligent game named "The number farm" used to identify learning difficulties and provide support to reduce the effect of learning difficulties on mathematical achievements. The intelligent game incorporates AI to analyse the results and adapt the difficulty level, as well as to evaluate each student's progress. The study incorporated the intelligent game into the mathematical learning of 41 students and found a positive correlation between students' mathematical achievements and their participation in the intelligent game. Flogie et al. (2020) extend their findings, showing that intelligent games improved students' overall well-being and academic skills, including motivation, self-esteem, attitude, communication, problem-solving, critical thinking, and classroom performance. Similarly, Dhingra et al. (2024) investigated the effect of an intelligent application, called Mathlete, on students with dyscalculia, finding a significant improvement in students' mathematical abilities compared to conventional teaching methods. Thus, a positive correlation exists between the use of the AI system and students' mathematical achievements. In a controlled study, Feizi et al. (2025) reported significant improvements in the mathematical abilities of 20 SEN students, including understanding the problem, planning a solution, solving the problem according to the designed plan, concluding, and overall mathematical problem-solving performance" (Feizi et al., 2025, p. 117). ChatGPT has received significant attention in the literature, with several studies (Polydoros, 2025; Polydoros et al., 2025; Rizos et al., 2024) observing an overall increase in mathematics achievements among SEN students and a reduction in mathematics anxiety following the incorporation of ChatGPT individualised worksheets into mathematics teaching.

The effect of AI incorporation in special education goes beyond direct mathematics achievement gains. AI systems have shown strong potential in early detection, personalised learning, and adapted teaching methods. AI systems develop personalised learning through algorithms that interpret and analyse students' "learning styles, strengths, weaknesses, and areas in which they need assistance" (Almulla & Amjad, 2025, p. 69). Bhushan et al. (2024) argue that early detection and intervention for learning disabilities can lead to a decrease in the impact of the disabilities on mathematics achievement. At the same time, AI systems can detect learning disabilities and provide targeted interventions to address the needs of the students.

Feizi et al. (2025) argue that AI tutoring systems can develop one-on-one simulations that can provide immediate feedback and respond according to each student's cognitive profile. To effectively accommodate SEN students in the teaching of mathematics, lessons should be adapted to include "clear and systematic teaching methods, including providing problem-solving models, expressing thought processes, guided practice, feedback, and regular review" (Vincent, 2024, p. 4), all of which can be obtained by incorporating AI systems in mathematics teaching of students with SEN. These adaptive teaching methods provide SEN students with the opportunity to achieve their learning objectives while fostering their independence throughout the process (Vincent, 2024). Providing SEN students with independence can significantly affect their overall attitude towards mathematical learning, in turn improving their willingness to study mathematics.

Another key advantage of incorporating AI technologies is their ability to reduce mathematics anxiety. Although mathematical anxiety is not seen as a learning disability, the effects of mathematical anxiety on students' mathematical achievements are significant. This can be attributed to the negative correlation between mathematical anxiety and learning disabilities (Vincent, 2024). Polydoros et al. (2025) concur that mathematical anxiety contributes to difficulties in understanding mathematics, as students experience fear and tension when faced with mathematical concepts. The study found that traditional teaching often omits accommodation strategies to address mathematics anxiety. Thus, a significant need exists to adapt traditional teaching to improve students' mathematics anxiety. Research has shown that AI systems can effectively reduce mathematics anxiety. Almulla and Amjad (2025) found that AI-adapted instruction reduces mathematical anxiety and stress as AI-generated lessons enable SEN students to engage with mathematical concepts in a manner they understand, rather than feeling frustrated due to their disabilities. Polydoros et al. (2025) concur that AI systems can develop individualised instruction that adapts to students' work pace and difficulty levels, thus reducing students' pressure when engaging with complex mathematical concepts.

Collectively, AI applications, such as intelligent games, tutoring systems, and individualised learning, can significantly enhance students' overall mathematics achievements, support students' emotional well-being, and foster student independence.

The benefits and limitations of using AI in the mathematics education of students SEN

Fourteen of the reviewed publications (2, 4, 5, 7, 8, 9, 13, 15, 17, 18, 19, 22, 25, 29) examined the benefits and limitations of AI incorporation in mathematics education for SEN students (see Appendix A). The findings highlight that AI presents significant opportunities for special mathematics education; however, notable limitations have been identified that need to be addressed to ensure the successful incorporation of AI-powered systems. As AI has made significant advancements in its ability to simulate human interaction, the education sector needs to be aware of the potential benefits and challenges that AI incorporation presents (Clark et al., 2025). Although the benefits of incorporating AI in special mathematics education have been widely highlighted, Gill et al. (2024) argue that there are still open debates regarding the role and influence of AI on mathematics education. While some authors see the benefits of AI in transforming learning and development, others view the threats to students' knowledge and problem-solving skills.

Several studies have found significant benefits to incorporating AI-powered systems into the mathematics education of SEN students. Reported benefits of incorporating AI chatbots into mathematical education include "enhanced personalisation, support and monitoring, level-appropriate adaptation, additional support, identification of weaknesses and efficient use of time" (Luong et al., 2025, p. 326). The studies consistently found that AI-powered systems enabled the incorporation of individualised lessons and inclusivity in special mathematics

education. AI chatbots, such as ChatGPT, have been found to develop personalised lessons, identify misconceptions, and continuously monitor students' progress. They adapt to their needs and skills, thereby addressing the gap between students' mathematical understanding and the outlined learning outcomes (Luong et al., 2025; Hibi, 2025). AI's effectiveness is not limited to mathematical achievements or teaching methods; it also significantly contributes to the emotional well-being of SEN students. Students with dyslexia, for instance, benefited from AI-powered lessons, which provided them with an isolated space, free from comparisons to other students, and a stress-free setting to understand mathematical concepts (Dhingra et al., 2024). Likewise, intelligent games and interactive systems created a more engaging educational experience, fostering participation in mathematics education for students with SEN (Flogie et al., 2020).

The effectiveness of AI incorporation is evident not only in the learning of mathematics by SEN students but also in the teaching of the subject. Educators reported significant benefits from incorporating AI, particularly in its ability to reduce workload and provide instructional support. Several studies have reported that AI-powered systems are beneficial in enabling teachers to differentiate their teaching by developing more relevant and engaging individualized worksheets, tailoring assessments, and providing targeted feedback. This reduces teachers' workload and time constraints (Polydoros et al., 2025; Rizos et al., 2024). Likewise, it has been reported that AI-powered systems provide significant benefits in large-scale assessments due to their ability to develop assessments, analyse a significant amount of data effectively, enable various measurement capabilities, and improve accessibility for SEN students (Clark et al., 2025). The benefits of incorporating AI are acknowledged by all parties involved in special education, as evidenced by teacher surveys that reveal a positive attitude towards using AI in mathematics education for students with SEN (Almulla & Amjad, 2025; Polydoros et al., 2025). At the same time, AI-powered systems facilitate communication among all stakeholders in mathematics education, as they provide continuous feedback to parents, teachers, and students (Almulla & Amjad, 2025). However, the complexity of academic support lies in its accessibility; therefore, when AI is implemented as a support system, education systems should ensure that all students have equal access to it (Hibi, 2025). Therefore, to experience these benefits in practice, attention should be given to the technological transformation in schools.

Despite the significant benefits that AI incorporation holds for the mathematics education of SEN students, several studies have identified important limitations. Several studies have raised ethical and pedagogical concerns about the potential reduction in the overall value of human-directed education, as reliance on AI-powered games or tutors could alter the role teachers play in mathematics education for students with SEN (Flogie et al., 2020). The efficiency of AI-powered systems, such as ChatGPT, was shown to be highly dependent on teachers' knowledge, as ineffective prompts result in ineffective learning materials. Additionally, large classes made individualised mathematics education more difficult (Rizos et al., 2024). While the user of AI systems influences the effectiveness of the systems, bias within these systems is another concern, as the biases among creators and the community are often encoded in AI algorithms; thus, the information produced may be discriminatory towards a particular group (Baker & Hawn, 2022).

Practical limitations were also noted, particularly in terms of financial and technical constraints. The cost of AI or VR systems, as well as the need for specialised software and training, were found to be prohibitive for schools in implementing such systems (Almulla & Amjad, 2025; Al Omoush & Mehigan, 2023). Students' lack of digital literacy was identified as another limitation, as they are not equipped with the necessary knowledge to utilise these systems. Hence, the studies emphasise the need to incorporate AI and other systems into the school curriculum to adapt to the increasing digital world (Luong et al., 2025). However, it has been observed that SEN students have inadequate access to technology. Therefore, for the

benefits of AI incorporation to be experienced by SEN students, this unequal access must be addressed (Hibi, 2025).

In summary, the findings suggest that AI-powered systems offer significant benefits for mathematics education among students with SEN. The evidence suggests that AI systems provide individualised learning opportunities (Luong et al., 2025; Hibi, 2025; Dhingra et al., 2024), reduce teacher workload and time constraints (Almulla & Amjad, 2025; Clark et al., 2025; Polydoros et al., 2025; Rizos et al., 2024), and improve communication with parents (Almulla & Amjad, 2025). However, for the benefits of AI mathematics incorporation to be experienced by SEN students, financial constraints (Al Omoush & Mehigan, 2023), ethical challenges (Baker & Hawn, 2022; Flogie et al., 2020; Rizos et al., 2024), teacher knowledge gaps (Rizos et al., 2024), and equal technology access (Hibi, 2025) must be addressed. Considering all the benefits AI systems offer for mathematics education, Luong et al. (2025) argue that AI systems can digitally transform mathematics education to provide more significant learning experiences. This transformation allows students to be more actively engaged during lessons, thereby contributing to the development of problem-solving skills. Such a transformation can lead to more student involvement, enhanced problem-solving skills, and equal access to quality mathematics education.

AI Applications in Special Education versus Conventional Methods

Four of the reviewed publications (11, 17, 24, 29) focused on comparing AI-directed learning with conventional methods in special mathematics education. The findings from these four studies were further analysed to compare AI applications in special education with conventional methods (see Table 5). Collectively, the studies revealed that although conventional methods play a role in special mathematics education, AI-powered systems provide significant advantages in terms of accessibility, diagnosis, individualisation, and teaching methodologies.

Table 4

The Findings of How AI Applications Compare to Conventional Methods

Conventional methods	Incorporation of AI
Confined to remedial schools	Global accessibility
Manual diagnosing processes that are time-consuming and subject to human error	AI-powered systems can provide fast and accurate diagnoses.
General teaching	Individualised teaching
General pedagogical approach	Combined pedagogical approach

One of the most prominent differences between the two approaches is accessibility. Conventional special education methods are often confined to remedial classes or schools, limiting opportunities for many students. By contrast, the incorporation of AI in special mathematics education does not require extensive infrastructure; thus, these benefits can also be experienced by students who would otherwise have been excluded (Almulla & Amjad, 2025).

The diagnostic process revealed important differences. Conventional diagnosis of learning difficulties typically involves a series of doctor-administered tests that increase in difficulty. Although this method is established, it is considered time-consuming and prone to human error (Bhushan et al., 2024). AI-powered systems, in contrast, can analyse a large amount of data in seconds, streamlining and enhancing the accuracy of this process, reducing the risk of misdiagnosis.

In terms of classroom support, AI systems were found to move beyond conventional methods by providing individualised and targeted support to SEN students. Conventional support for SEN students includes providing additional time on assessments and a variety of instructional materials in different formats. While some form of flexibility is incorporated into conventional special education methods, these methods cannot fully accommodate each individual's unique learning needs (Hibi, 2025). AI-powered systems have consistently moved beyond traditional methods by providing individualised and targeted support to students with SEN, which equalises education and offers opportunities to students that traditional teaching methods would have excluded (Hibi, 2025).

Finally, the studies revealed that the methodological approaches of AI differ significantly from those of conventional methods. Conventional methods have been grounded on Behaviourism, Cognitivism, and Constructivism, offering a broad theoretical approach, but limiting their ability to adapt to students' individual needs. AI introduced a combination of these theories and individualised approaches, producing a hybrid model of special mathematics education (Feizi et al., 2025). This combination enables a more targeted and tailored education system, which was previously not possible with traditional teaching methods.

In summary, the studies revealed that AI systems offer significant advantages over conventional methods. AI systems enhance accessibility, accelerate diagnosis, provide individualised learning, and produce a hybrid pedagogical model. Although conventional methods continue to provide foundational support, AI systems have the potential to augment and enhance conventional methods, contributing to the reform of mathematics education for students with SEN.

Applications of AI in Supporting Students with Specific Disabilities

Nine of the publications (1, 2, 4, 6, 8, 14, 17, 27, 29) focused on how AI systems can be incorporated in mathematics education to support students with special educational needs. Collectively, the studies indicated that AI systems provide significant support in the form of individualised learning opportunities, early diagnosis, teacher decision-making, and enhanced engagement.

A consistent finding across the studies was that AI systems enable individualised learning opportunities for SEN students. AI-powered systems have been shown to develop mathematical support that caters to each student's individual learning needs, provide fast and effective feedback, and continuously adapt the mathematical support in response to students' progress. AI chatbots, for example, were found to deliver individualised lessons, provide immediate feedback, and offer support for challenging concepts, while continuously analysing and adapting the lessons according to students' responses, ensuring that students receive ongoing, targeted support (Luong et al., 2025). The evidence shows that individualised teaching and learning of mathematics is one of the most effective ways AI supports mathematics education for students with SEN (Almulla & Amjad, 2025; Gill et al., 2024; Luong et al., 2025; Rizos et al., 2024; Vincent, 2024).

Several studies have reported on the role of AI in the early detection of learning difficulties. AI-powered tools have demonstrated significant accuracy in diagnosing learning disabilities, with some systems achieving an 80% success rate in identifying these conditions (Kariyawasam et al., 2019). Other studies have demonstrated that AI systems can analyse students' test results and calculate the probability of learning disabilities, providing an opportunity for early detection, which in turn offers opportunities for early intervention (Bhushan et al., 2024). Early intervention was consistently linked to more effective outcomes, highlighting the value of the support that AI systems can provide in special mathematics education through early detection of learning disabilities (Hornos-Arias et al., 2024; Orefice, 2022; Vincent, 2024). Early detection

has been shown to reduce the impact of learning disabilities, as young brains can be trained to prevent the development of these conditions (Hornos-Arias et al., 2024; Orefice, 2022).

Beyond diagnosis, the studies have indicated that AI-powered systems support decision-making by identifying the best-suited teaching methodology for each student with special needs. AI systems were found to test several methodologies in special mathematics education teaching and then determine the most effective methodology for each student (Zingoni et al., 2021). Evidence also showed that AI significantly contributes to open communication between educators and parents, providing fast and correct assistance (Almulla & Amja, 2025). These findings suggest that the capabilities of AI in special education not only support the teaching of mathematics but also enhance teachers' teaching practices.

The integration of AI-powered educational games and virtual reality (VR) environments was indicated to provide an environment that fosters inclusive education while engaging in creative mathematics education. A well-designed academic game provides a sense of achievement, happiness, and pleasure, all of which affect students' overall well-being and, in turn, impact their ability to learn (Flogie et al., 2020). VR systems were particularly beneficial for SEN students due to their ability to retain students' focus, which is often a difficulty among students with learning difficulties (Al Omoush & Mehigan, 2024). However, studies have consistently indicated that human interactions should be at the forefront of special education teaching. For example, a large-scale study involving 700 students found that students preferred human interaction over AI voices or tutors (Zingoni et al., 2021).

However, the successful use of AI in supporting SEN students is dependent on equitable access to technology. Studies have shown that individuals with disabilities often lag behind in computer use and internet access. When they do use technology, they tend to participate in communication less frequently (Scanlan, 2022). This digital divide presents a barrier to fully experiencing AI's potential benefits in special mathematics education.

Overall, the studies reviewed indicated that AI-powered systems support special mathematics education in four primary ways: by enabling individualised teaching and learning, fostering early diagnosis and intervention of learning disabilities, supporting teacher decision-making, and increasing engagement through intelligent games and VR. However, limitations continue to persist, highlighting the need for inclusive technology implementation.

Discussion

The systematic literature revealed that intelligent games (11 publications) emerged as the most implemented AI-powered tool among the 30 publications included in the study. The predominant implementation of intelligent games highlights the significant benefits that learning by play offers to special mathematics education. This approach has been observed to provide more engaging mathematical lessons that adapt to students' individual needs (Blangiardi, 2023; Orefice, 2022). Intelligent games are closely followed by chatbots (7 publications), intelligent tutoring systems (6 publications), and personalised learning systems (5 publications). Chatbots have been valued in the teaching of mathematics to SEN students for their ability to provide individualised support and to analyse students' misconceptions in real time (Luong et al., 2025). Less implemented AI-powered systems include intelligent robots and virtual reality (each with two publications). In contrast, communication aids, classroom simulation tools, and virtual instructional coaches were found to be scarcely implemented. This finding suggests that AI-powered systems, which require minimal infrastructure demands and are easily accessible, are favoured in educational practice.

The effectiveness of AI-powered systems in enhancing students' mathematical achievements has been found in several studies. All the articles examining the effect of AI systems on students' mathematical achievements (9 publications) found a positive result.

Evidence suggests that AI-powered systems enhance students' mathematical achievements by developing their critical thinking, problem-solving abilities, and motivation to learn. Furthermore, AI systems not only improve students' mathematical achievements but also improve their self-esteem and classroom engagement (Dhingra et al., 2024). Notably, tools such as ChatGPT demonstrated the ability to provide individualised learning opportunities, targeting students' individual needs and skills, which is a valuable asset in special needs education (Almulla & Amjad, 2025; Rizos et al., 2024).

The studies' findings also indicate AI's ability to reduce mathematical anxiety, which is a significant barrier to mathematics education for SEN students (Polydoros et al., 2025). Overall, AI-powered systems contribute to the mathematical achievements of SEN students by providing interactive and individualised lessons that continuously adapt to the students' misconceptions and needs. These abilities ensure that SEN students receive targeted mathematical education tailored to their specific needs, thereby improving their overall well-being in the mathematics classroom.

According to the findings of the incorporated publications, AI-powered systems offer three primary benefits to mathematics education for students with SEN, namely personalisation, efficiency, and accessibility. Several studies have highlighted the ability of AI-powered systems to provide personalised lessons that adapt to the skills, difficulty level, and pace of SEN students, ensuring their needs are met. Furthermore, the studies found that the efficiency of AI systems is another benefit of special mathematics education. These systems enable the rapid development of assessments while also providing feedback and diagnosing learning difficulties in students. This benefit significantly reduces the workload of teachers while also minimising the time and human errors associated with diagnosing learning disabilities. Accessibility is another significant benefit of mathematics education for students with SEN, as AI systems move beyond remedial classrooms to reach these students in rural or underdeveloped areas that would have otherwise been left out.

However, limitations persist. Ethical concerns, potential bias in algorithms, high financial implications, and teachers' knowledge of AI systems are recurring challenges seen in the implementation of AI systems (Almulla & Amjad, 2025; Baker & Hawn, 2022). Flogie et al. (2020) note that over-reliance on AI-powered learning can reduce interactions among students. While access remains a critical barrier, evidence has shown that SEN students often face a digital divide in terms of access and technology use (Scanlan, 2022).

Although limitations persist, the advantages of AI systems remain substantial. AI-powered systems can transform the traditional teaching of mathematics education for students with SEN. AI-generated education differs widely from traditional teaching. Several studies included in the review have found that AI-generated teaching widely differs from traditional teaching. The studies have found that AI-generated teaching offers advantages in the diagnosis process, personalised teaching, and global accessibility. In contrast, traditional special education is confined to remedial classes and manual assessment in the diagnosis process. Furthermore, AI's ability to transform the pedagogical approach to special mathematics education, by combining several learning theories (Feizi et al., 2025), ultimately presents a new educational paradigm.

Considering all the benefits AI systems offer for the mathematics education of SEN students, several studies have found that AI systems can be effectively incorporated into these lessons to support them. AI systems have been incorporated to support individuals with a range of disabilities through targeted lessons, adaptive games, virtual reality lessons, and diagnostic tools. These systems can help inform teachers about their misconceptions, provide suitable teaching methods, and offer tailored assessments, while also offering interactive and gamified support (Vincent, 2024; Zingoni et al., 2021).

Overall, AI systems show significant potential in transforming mathematics education for SEN students, providing personalised, engaging, and inclusive mathematics education.

Incorporating support for each student's individual needs and disabilities has been a challenge in special education for several years; however, AI systems can address this need. However, Zingoni et al. (2021) found that although AI in special education is increasing, technology has yet to reach its full potential in supporting students with SEN. This is evident in the trends of AI in special education found in the literature, as Govea et al. (2023) found that several studies focus on the abstract application of AI rather than empirical data. Thus, the current body of knowledge on the application of AI in special education is mainly based on its potential rather than evidence and observations. Thus, to experience these benefits in practice, special education will be required to address barriers seen, such as cost, teacher readiness, and closing the digital gap among SEN students.

Conclusions and Implications

The review highlighted the growing role that AI systems play in supporting the mathematics education of SEN students. Evidence from the literature included in the review demonstrates that AI systems hold significant potential to transform mathematics education into a more interactive, engaging, and personalised form, tailoring lessons to fit each student's needs. Compared to conventional teaching methods, AI enables the early detection of learning disabilities, greater accessibility, and personalised education. However, limitations such as cost, ethical considerations, and teacher readiness may hinder the incorporation of AI systems in special mathematics education. Thus, AI should not be seen as a replacement for human-led teaching, but rather as a powerful complement to teaching.

This research highlights the meaningful role of AI in mathematics education for SEN students. By providing personalised learning, immediate feedback, and adaptive instructional support, AI can enhance students' engagement, confidence, and overall achievement in mathematics. Beyond the classroom, these findings have practical relevance for educators, policymakers, and developers seeking strategies to improve inclusive education. Internationally, the study contributes to the growing conversation on how AI can support learners with diverse needs. It demonstrates both the potential of AI to make mathematics education more accessible and the challenges that must be addressed, such as teacher readiness, ethical concerns, and unequal access to technology. Overall, this research underscores the value of integrating AI thoughtfully to promote equitable, effective, and engaging learning experiences for SEN students worldwide.

Moving forward, the success of incorporating AI in mathematics education for SEN students depends on the collaboration of teachers, technology developers, and stakeholders. By fostering these collaborations, AI can move from an experimental intervention to a valuable tool of inclusive mathematics education.

Declaration of Interest

The authors declare no competing interest.

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Appendix A: Reviewed articles

	Article	Authors	Year	Source	Country	Type of AI Application incorporated
1	A Survey of Using Artificial Intelligence (AI) in Sign Language for Deaf and Hard-of-Hearing Students	Khandaqji, F., Ashqar, H. I., & Atawnih, A.	2025	Scopus	Palestine	Chatbots, tutoring systems and augmented realities
2	A Technology-Driven Assistive Learning Tool and Framework for Personalized Dyscalculia Interventions	Jadhav, D., Chettri, S. K., Tripathy, A. K., & Saikia, M. J.	2025	ProQuest	USA & India	An intelligent tutoring
3	A tutoring math platform accessible to visually impaired people	Maćkowski, M. S., Brzoza, P. F., & Spinczyk, D. R.	2018	Google Scholar	Poland	Intellectual tutoring system for the visually impaired

	Article	Authors	Year	Source	Country	Type of AI Application incorporated
4	AI-Enhanced Dyscalculia Screening: A Survey of Methods and Applications for Children	Bhushan, S., Arunkumar, S., Eisa, T. A. E., Nasser, M., Singh, A. K., & Kumar, P.	2024	Google Scholar	Malaysia / India and Saudi Arabia	intelligent tutors, chatbots, communication aids, adaptive learning devices, intelligent robots, mastery learning devices, and facial recognition software
5	Algorithmic bias in education.	Baker, R. S., & Hawn, A.	2022	Google Scholar	USA	
6	Artificial intelligence in school mathematics education: awareness, readiness, and usage among mathematics teachers	Kuzmenko, M.V.	2025	Scopus	Russia	Chatbots
7	Artificial intelligence in science and mathematics assessment for students with disabilities: Opportunities and challenges.	Clark, A. K., Hirt, A., Whitcomb, D., Thompson, W. J., Wine, M., & Karvonen, M.	2025	Google Scholar	USA	chatbots, intelligent tutors, personalised learning systems, educational data analytics, virtual reality platforms, game-based applications, classroom simulation tools, and virtual instructional coaches
8	Artificial Intelligence: An Untapped Opportunity for Equity and Access in STEM Education	Kohnke, S., & Zaugg, T.	2025	ProQuest	USA	adaptive learning platforms and intelligent tutors
9	Challenges and Design Opportunities for AI-Based Tutoring and Assessment Software in Special Education: An Interview Study with Teachers	Williams, C. N., Seehorn, M. E., Zhu, H., & Alevan, V.	2025	Scopus	USA	
10	<i>Design of an AI-based Game for prevention of Dyscalculia</i>	Orefice, I.	2022	Google Scholar	Italy	Intelligent games
11	Designing an AI-Based Learning Program and Evaluating Its Effectiveness on Problem-Solving Skills of Students with Mathematical Learning Disabilities.	Feizi, F., Zaraii Zavaraki, E., Sharifidaramadi, P., Rashidi, H., & Jafarkhani, F.	2025	Google Scholar	Iran	

	Article	Authors	Year	Source	Country	Type of AI Application incorporated
12	<i>Designing the AI for The Number Farm: a Gaming Application for treating Dyscalculia</i>	Blangiardi, F.	2023	Google Scholar	Italy	Intelligent games
13	Development and evaluation of intelligent serious games for children with learning difficulties: observational study.	Flogie, A., Aberšek, B., Kordigel Aberšek, M., Sik Lanyi, C., & Pesek, I.	2020	Google Scholar	Slovenia and Hungary	Intelligent games
14	<i>DEVELOPMENT OF AN AI ASSISTIVE TOOL FOR IDENTIFYING MATHEMATICAL DIFFICULTIES IN CHILDREN (3RD GRADE)</i>	VINCENT, M.	2024	Google Scholar	India	Personalised learning
15	Educational Robotics and Game-Based Interventions for Overcoming Dyscalculia: A Pilot Study	Stasolla, F., Curcio, E., Borgese, A., Passaro, A., Di Gioia, M., Zullo, A., & Martini, E.	2025	ProQuest	Italy	Serious games and Robotics
16	Effects of mathematics computer games on special education students' multiplicative reasoning ability	Bakker, M., van den Heuvel, Panhuizen, M., & Robitzsch, A.	2016	Google Scholar	Netherlands	Computer games
17	Emerging Trends of Using Artificial Intelligence in Developing Strategies to Handle the Students with Learning Disabilities in the Subject of Mathematics	Almulla, A. A., & Amjad, F.	2025	Google Scholar	Pakistan & Saudi Arabia	Gamified learning platforms and adaptive assessment
18	EMPOWERING LEARNING: ICT ASSISTIVE TECHNOLOGIES FOR STUDENTS WITH LEARNING DISABILITIES IN INDIA	Kumari, A., Gautam, J., & Gautam, V. K.	2025	ProQuest	India	Tutoring systems
19	Enhancing Mathematics Education for Students with Special Educational Needs through Generative AI: A Case Study in Greece.	Rizos, I., Foykas, E., & Georgakopoulos, S. V.	2024	Google Scholar	Greece	ChatGPT
20	Harnessing AI and digital tools for micro-credentialing in mathematics education: Enhancing learning outcomes for students with learning difficulties.	Polydoros, G. V.	2025	Google Scholar	Greece	ChatGPT

	Article	Authors	Year	Source	Country	Type of AI Application incorporated
21	Innovative AI-Driven Approaches to Mitigate Math Anxiety and Enhance Resilience Among Students with Persistently Low Performance in Mathematics.	Polydoros, G., Galitskaya, V., Pergantis, P., Drigas, A., Antoniou, A. S., & Beazidou, E.	2025	Google Scholar	Greece	
22	Investigating issues and needs of dyslexic students at university: Proof of concept of an artificial intelligence and virtual reality-based supporting platform and preliminary results	Zingoni, A., Taborri, J., Panetti, V., Bonechi, S., Aparicio-Martínez, P., Pinzi, S., & Calabrò, G.	2021	Google Scholar	Italy & Spain	
23	Mathlete: An adaptive assistive technology tool for children with dyscalculia.	Dhingra, K., Aggarwal, R., Garg, A., Pujari, J., & Yadav, D.	2024	Google Scholar	India and the UK	Intelligent game
24	Personalised presentation of mathematics for visually impaired or dyslexic students: Challenges and benefits.	Al Omoush, M. H., & Mehigan, T.	2023	Google Scholar	Ireland	Robots & Virtual Reality
25	Personalized Mathematics Teaching with The Support of AI Chatbots to Improve Mathematical Problem-Solving Competence for High School Students in Vietnam.	Luong, V. T., Long, T. T., & Linh, N. T. T.	2025	Google Scholar	Vietnam	Chatbots
26	Prototyping a Mobile Application for Children with Dyscalculia in Primary Education using Augmented Reality	Lazo-Amado, M., Cueva-Ruiz, L., & Andrade-Arenas, L.	2022	Google Scholar	Peru	
27	Pubudu: Deep learning based screening and intervention of dyslexia, dysgraphia, and dyscalculia.	Kariyawasam, R., Nadeeshani, M., Hamid, T., Subasinghe, I., Samarasinghe, P., & Ratnayake, P.	2019	Google Scholar	Sri Lanka	Intelligent game
28	Screening test on dyscalculia learners to develop a suitable augmented reality (AR) assistive learning application	Miundy, K., Zaman, H. B., Nordin, A., & Ng, K. H.	2019	Google Scholar	Malaysia	

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	Article	Authors	Year	Source	Country	Type of AI Application incorporated
29	Serious Games and Artificial Intelligence for the detection of mathematical difficulties at school	Hornos-Arias, J., Serra-Grabulosa, J. M., Gómez-Berengueras, J., & Grau-Carrion, S.	2024	Google Scholar	Barcelona	Serious games and personalised learning systems
30	The ICT usage in teaching mathematics to students with special educational needs	Kramarenko, T., Bondar, K., & Shestopalova, O.	2021	Google Scholar	Ukraine	

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Mary-Jane Lessing
(Corresponding author)

University of Pretoria, South Africa
E-mail: u22822977@tuks.co.za
ORCID: <https://orcid.org/0000-0002-2866-1885>

Ugorji Iheanachor Ogbonnaya

PhD, Professor, University of Pretoria, South Africa.
E-mail: ugorji.ogbonnaya@up.ac.za
ORCID: <https://orcid.org/0000-0002-6243-5953>