© IIJP 2026 | Volume 2, Issue 2, pp. 520-529 | ISSN: 2636-4484

ENHANCING MATHEMATICAL LEARNING OUTCOMES FOR STUDENTS WITH SPECIAL NEEDS THROUGH ASSISTIVE TECHNOLOGY IN INCLUSIVE CLASSROOMS

***Muhammad Hamma PhD[1], Yahaya Umar Magaji, PhD[2] & Nasir Gambo[3]**
[1]*Department of Educational Foundations, Sa'adu Zungur University, Gadau*
[2]*Department of Educational Psychology, Federal College of Education, Yola*
[3]*Department of Educational Psychology, Aminu Sale College of Education, Azare*
***Corresponding Author:** *hammamuhammad@gmail.com/muhammadhamma@sazu.edu.ng*

ARTICLE INFO
Article No.: 0306
Accepted Date: 01/04/2026
Published Date: 30/04/2026
Type: Research

ABSTRACT
This study explores the impact of assistive technology on the mathematical performance of students with special needs in inclusive classrooms. In the context of inclusive education, equitable access to quality instruction in mathematics remains a significant challenge for learners with disabilities. Using a mixed-method approach, the study examines the types of assistive technologies available, their effectiveness in improving learning outcomes, and teachers' experiences in implementing them. Findings suggest that students who accessed tailored assistive tools, such as talking calculators and math-related mobile applications, showed notable improvement in computational fluency and conceptual understanding. The study concludes with recommendations for policy implementation, teacher training, and improved resource allocation.

Keywords: assistive technology, inclusive education, special needs students, mathematics achievement, learning outcomes, educational intervention

Introduction

Education is universally recognised as a fundamental human right and a vital tool for personal and societal development. In line with global educational frameworks such as the United Nations Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive and equitable quality education for all, many countries, including Nigeria, have embraced inclusive education policies to accommodate learners with special needs in mainstream classrooms (UNESCO, 2020a). Inclusive education ensures that students, regardless of physical, intellectual, social, emotional, linguistic, or other conditions, learn together in the same environment with appropriate supports.

One of the most challenging subjects in the inclusive education setting is mathematics, owing to its abstract nature and heavy reliance on logical reasoning, spatial understanding, memorization, and symbol manipulation. For students with special needs, especially those with cognitive disabilities, dyscalculia, visual or hearing impairments, and attention disorders, accessing and mastering mathematical concepts can be daunting (Chigonga, 2021; Obiakor & Rotatori, 2018). In the absence of appropriate interventions, these learners often lag behind their peers, resulting in low academic achievement, diminished confidence, and increased dropout rates.

Assistive Technology (AT) offers a transformative opportunity to address these challenges. AT refers to any device, software, or equipment that helps students with disabilities overcome learning barriers and achieve better academic outcomes (Dell et al., 2017). In mathematics, such technologies include talking calculators, digital manipulatives, screen readers, math-specific mobile applications, braille embossers, and tactile graphic tools. These tools not only support content accessibility but also promote learner engagement, independence, and confidence.

Despite the potential of assistive technology, its integration into inclusive mathematics classrooms, particularly in low- and middle-income countries like Nigeria, faces numerous obstacles. These include limited access to AT devices, lack of teacher training, inadequate policy implementation, and poor infrastructure (Yusuf & Nwosu, 2022a). While the Nigerian government has made strides in inclusive education through policy initiatives and special education interventions, gaps remain in the practical application of assistive tools for enhancing mathematics learning outcomes.

This study, therefore, seeks to investigate the extent to which assistive technology improves the mathematical learning outcomes of students with special needs in inclusive classrooms. It further examines the types of AT tools commonly used, the challenges faced by teachers and learners in implementing them by explaining, what type of assistive technology tools are commonly used in teaching mathematics to students with special needs in inclusive settings; what are the perceptions and experiences of teachers and students regarding the effectiveness of assistive technology in enhancing mathematics learning, what challenges affects the effective integration of assistive technology in inclusive mathematical classroom and provides recommendations for better integration. The significance of this study lies in its potential to inform educational policy, teacher training, and curriculum development, thereby contributing to a more inclusive and effective mathematics education for all learners.

Literature Review

The integration of assistive technology (AT) in inclusive education has been extensively discussed in recent educational research as a means of bridging the learning gap for students with disabilities. In the context of mathematics education, various studies have underscored the

importance of AT tools in addressing challenges that hinder the academic performance of students with special needs (Bryant et al., 2015; Edyburn, 2020). Uzoechina and Onu (2024) reported that although access to assistive technologies remains uneven, their effective use leads to measurable improvements in students' academic outcomes and motivation. The study emphasizes the need for policy enforcement and infrastructure development to support sustainable AT integration.

Inclusive education promotes the full participation of all students, including those with physical, sensory, cognitive, and learning disabilities, in general education settings. In Nigeria and other developing countries, implementation is guided by the National Policy on Education and international frameworks such as the Salamanca Statement (UNESCO, 1994) and UN Convention on the Rights of Persons with Disabilities (UNCRPD, 2006). However, mathematics is often cited as one of the most difficult subjects for students with special needs due to its abstract symbols, logical reasoning requirements, and sequential nature (Mutai, 2010).

Studies have shown that learners with disabilities, such as dyscalculia, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), or visual impairments, are particularly disadvantaged in conventional mathematics classrooms (Obiakor & Bakken, 2016). For example, dyscalculic learners struggle with number sense and arithmetic operations, while visually impaired students face challenges in interpreting graphical data and using traditional math materials such as rulers and charts (Okonkwo & Eze, 2022).

Assistive technology encompasses a broad range of tools, including low-tech devices (e.g., abacuses, number lines, manipulatives) and high-tech digital solutions (e.g., screen readers, tactile math software, interactive apps). These technologies help in presenting mathematical concepts in accessible formats, enhancing understanding and retention (Dell et al., 2017). Okonkwo and Eze (2022) found that assistive tools such as tactile graphics, audio-supported applications, and screen readers greatly enhance conceptual understanding among students with visual impairments. These technologies provide alternative pathways for accessing mathematical content, thereby reducing dependency on traditional visual-based instruction.

For example, talking calculators enable students with visual impairments or reading difficulties to hear their inputs and results. Virtual manipulatives, digital versions of physical math tools, allow learners to visualize abstract concepts such as fractions, geometry, and algebra (Maccini & Gagnon, 2016). Bouck et al. (2023) found that the use of virtual manipulatives and digital math tools led to improved problem-solving skills among students with intellectual disabilities. Their study confirms that interactive technologies help bridge the gap between concrete and abstract mathematical concepts. Text-to-speech software assists students with reading difficulties in accessing math word problems, while speech-to-text tools help students with motor challenges to input numerical data without physical writing.

Numerous studies have reported the positive impact of AT on students' academic performance in mathematics. According to Al-Azawei et al. (2019), students with learning difficulties who used math-based software in inclusive classrooms showed improved test scores and greater engagement compared to those using traditional methods. Similarly, a study by Bouck et al. (2017) revealed that students with intellectual disabilities who used digital math manipulatives performed significantly better on problem-solving tasks.

In Nigeria, Uzoechina and Onu (2020) found that the use of assistive tools like audio-based learning devices and math-related mobile apps significantly improved performance and participation among students with special needs in selected inclusive schools. However, they also noted limitations such as poor teacher preparedness, lack of infrastructure, and limited access to

digital devices. Also, Yusuf and Nwosu (2022b) and World Bank (2023) reports highlight issues such as poor infrastructure, lack of technical support, high cost of devices, and insufficient professional development for teachers. These barriers limit the full implementation and effectiveness of AT in inclusive classrooms

While the benefits of AT in mathematics learning are well documented, most studies are concentrated in developed countries with advanced infrastructure and resources. In the Nigerian context, there is a scarcity of comprehensive, empirical research focusing specifically on mathematics outcomes in inclusive classrooms using AT. Furthermore, existing studies often focus on primary education or general academic achievement, rather than subject-specific outcomes. Additionally, many studies do not sufficiently address the perspectives of both teachers and students in real classroom contexts, nor do they explore the practical challenges of AT integration, such as cost, maintenance, teacher training, and policy support. These gaps highlight the need for contextualized research that evaluates the impact of AT on mathematics achievement among students with special needs in Nigerian inclusive schools.

Methodology

This study employed a mixed-method research design, combining both quantitative and qualitative approaches to gain a comprehensive understanding of how assistive technology (AT) enhances mathematical learning outcomes among students with special needs in inclusive classrooms. The rationale behind this choice was to collect both numerical data on academic performance and contextual insights from educators and learners on the practical use and impact of AT. A descriptive survey design was used to quantitatively examine the relationship between the use of assistive technology and students' mathematics achievement. In parallel, case study and focus group discussions (FGDs) were employed qualitatively to explore the lived experiences, perceptions, and challenges faced by teachers and students when implementing AT tools in inclusive settings.

The target population included teachers and students with special needs in selected inclusive public and private schools across Bauchi State, Nigeria. A purposive sampling technique was used to select 8 inclusive primary and secondary schools, 120 students with special needs (e.g., visual impairments, learning disabilities, ADHD, autism spectrum), 32 mathematics teachers trained in inclusive pedagogy, 8 head teachers or special education coordinators.

Multiple data collection instruments were used include:

1. Mathematics Achievement Test (MAT): A standardized test aligned with the curriculum was administered pre- and post-intervention to evaluate changes in students' performance.
2. Teacher and Student Questionnaires: Structured questionnaires with Likert-scale and open-ended items were used to gather data on the types of AT used, frequency of use, perceived effectiveness, and challenges.
3. Interview Guide: Semi-structured interviews were conducted with teachers and special education coordinators to gather qualitative data on their experiences, training background, and observations.
4. Focus Group Discussion (FGD) Guide: FGDs were held with students with special needs to allow them to express how AT helped (or failed to help) them in learning mathematics.
5. Classroom Observation Checklist: A tool used by the researchers to record real-time AT usage, instructional strategies, student engagement, and classroom accommodations.

Baseline assessment of students' mathematics performance using MAT, Intervention phase, where teachers integrated various AT tools such as talking calculators, digital math apps,

abacuses, Braille materials, and tactile graphics during math lessons, Post-intervention assessment to measure academic progress, Administration of questionnaires and conducting of interviews and FGDs, Classroom observations conducted weekly to monitor AT use and learner engagement.

Quantitative data (test scores and questionnaire responses) were analyzed using descriptive statistics (mean, frequency, percentage) and inferential statistics (paired-sample t-test and correlation analysis) via SPSS software version 25. The aim was to test the significance of changes in mathematics achievement before and after AT use, while Qualitative data (interview and FGD transcripts, observation notes) were analyzed using thematic content analysis. Transcripts were coded and grouped into themes such as effectiveness of AT, student engagement, teacher challenges, and institutional support.

The validity of the instruments was ensured through expert review by professionals in special needs education and mathematics education, a pilot study was conducted in one inclusive school not involved in the main study to test the clarity and reliability of the instruments, the reliability coefficient of the Mathematics Achievement Test was calculated using the Cronbach's Alpha method, yielding a value of 0.83, which indicates high reliability.

Results

This section presents the findings of the study based on the analysis of quantitative and qualitative data. The results are presented under the following sub-headings:

- Comparison of students' mathematics performance before and after the use of assistive technology (AT)
- Frequency and type of AT usage
- Teachers' and students' perceptions of AT effectiveness
- Observed changes in student engagement and learning behavior

Improvement in Mathematics Achievement Scores

A paired-sample t-test was conducted to determine whether the use of assistive technology had a statistically significant effect on the students' performance in mathematics.

Table 1: Pre- and Post-Test Mean Scores of Students

Test Type	Mean Score	Std. Deviation	N
Pre-Test	43.25	11.48	120
Post-Test	61.80	10.37	120

Table 2: Paired Samples t-Test Result

Variables	Mean Difference	T	df	Sig. (2-tailed)
Pre-Test vs Post-Test	18.55	14.82	119	0.000

Interpretation:

There was a statistically significant improvement in students' mathematics scores after the use of AT tools ($p < 0.05$). The mean score increased from 43.25 to 61.80, suggesting that AT positively impacted mathematics achievement for students with special needs.

Types and Frequency of Assistive Technology Usage

Data gathered through teacher and student questionnaires identified the most commonly used assistive technologies during the intervention.

Table 3: Types and Frequency of AT Tools Used in Mathematics Classes

Assistive Technology	Frequently Used (%)	Occasionally Used (%)	Rarely Used (%)
Talking Calculator	76%	20%	4%
Digital Math Apps (e.g., MathTalk)	58%	32%	10%
Braille Math Materials	52%	34%	14%
Tactile Graphics	40%	45%	15%
Abacus	62%	30%	8%
Screen Readers	**33%**	**48%**	**19%**

Talking calculators, abacuses, and digital math apps were the most frequently used tools. Braille and tactile graphics were used primarily for visually impaired students, while screen readers had more moderate usage.

Teachers' Perception of AT Effectiveness

Teachers rated the effectiveness of AT on a Likert scale (1 = Not Effective, 5 = Very Effective).

Table 4: Teachers' Perceptions on AT Effectiveness

Effectiveness Area	Mean Score (Max = 5)
Enhances Concept Understanding	4.6
Improves Learner Engagement	4.4
Supports Independent Learning	4.2
Reduces Math Anxiety	3.9
Increases Assessment Performance	4.5

Student Engagement and Motivation

Classroom observations and focus group discussions revealed increased engagement levels and positive attitudes towards mathematics.

Observation Highlights:

80% of students with AT tools remained focused during entire math lessons.

Students showed increased willingness to solve problems independently.

Peer collaboration improved, especially with shared devices (e.g., talking calculators, apps).

Qualitative Quotes from Students:

"I can now solve problems on my own because my calculator talks to me."

"Before, I was scared of math, but now I like using the math app to learn every day."

Discussion

The findings of this study highlight the significant role assistive technology (AT) plays in enhancing mathematics learning outcomes for students with special needs in inclusive classrooms. The results reveal marked improvements in academic performance, learner engagement, and classroom participation, aligning with global and national research emphasizing the importance of inclusive technology in education (Adebisi et al., 2022; UNESCO, 2020b).

The most notable outcome of this study is the significant increase in students' mathematics achievement scores following the introduction of AT tools. The mean score improvement from 43.25 to 61.80 (with a *p*-value of 0.000) confirms the hypothesis that AT contributes positively to cognitive understanding and retention in mathematics. This supports the findings of Okonkwo and Nwafor (2018), who reported that visually impaired learners using tactile math materials outperformed their peers who relied solely on oral instruction. Moreover, the improvement correlates with the principles of Vygotsky's Zone of Proximal Development

(ZPD), suggesting that with the right scaffolding, here provided by AT, students with disabilities can reach learning levels comparable to their typically developing peers (Vygotsky, 1978).

Talking calculators, abacuses, and math applications emerged as the most effective and frequently used technologies. These tools provided immediate feedback, auditory support, and tactile engagement, making abstract mathematical concepts more accessible. This aligns with the work of Alnahdi (2020), who noted that technology-driven interventions often lead to better comprehension in subjects like math, where symbolic reasoning is critical.

Interestingly, while screen readers and tactile graphics were less frequently used, they played a vital role for students with visual impairments, reinforcing the need for individualized AT choices tailored to specific disability types. The diversity in AT effectiveness emphasizes that a "one-size-fits-all" approach is inadequate in inclusive education (Chitiyo & Wheeler, 2009).

Teachers' responses reflected strong approval for AT, especially in enhancing conceptual understanding (mean rating of 4.6 out of 5) and increasing assessment performance (4.5). Teachers also noted reduced math anxiety among students, which is a major barrier for learners with learning disabilities (LD) and attention-related disorders (Mutasa & Sithole, 2021). Students, on their part, described the tools as "friendly," "encouraging," and "helpful," showing increased motivation and independence. These findings resonate with the Universal Design for Learning (UDL) framework, which advocates for flexible, technology-enhanced learning environments to accommodate diverse learners (CAST, 2018). Beyond academic gains, the classroom observation data and focus group discussions showed improved engagement levels and peer collaboration. This confirms prior research by Obielodan and Adeniji (2019), who found that the integration of AT in inclusive classrooms fosters social inclusion, particularly for students who otherwise face stigmatization or withdrawal.

While the benefits of AT are clear, challenges persist. Some schools reported inconsistent electricity, outdated devices, and lack of internet connectivity, issues previously highlighted in UBEC (2021) reports. Additionally, not all teachers were adequately trained in the use of AT, suggesting a capacity gap that could limit sustained success if not addressed. This study corroborates prior empirical findings while offering fresh data specific to Bauchi State. While global literature affirms the value of AT (World Bank, 2021; Alkahtani, 2013), this research provides localized evidence supporting government investment and teacher capacity-building in AT integration.

Conclusion

This study examined the impact of assistive technology (AT) on the mathematics performance of students with special needs in inclusive classrooms. The results showed a significant improvement in learners' academic achievement, engagement, and confidence when AT was effectively used. Tools such as talking calculators, abacuses, Braille math kits, and math apps played a crucial role in helping students overcome traditional barriers to mathematics learning. Moreover, the findings confirm that assistive technology is not only a supportive tool but also a transformative element in inclusive education. It bridges the learning gap between students with special needs and their peers by making instruction accessible, interactive, and individualized. Teachers and students alike perceived AT positively, citing increased participation, comprehension, and independence in mathematical problem-solving. Despite these successes, challenges such as limited teacher training, insufficient infrastructure, and lack of device maintenance remain areas of concern. If addressed, the full potential of AT in inclusive settings can be realized across Nigerian schools and beyond.

Recommendations

Based on the findings and conclusions, the following recommendations are proposed:

1. Government, NGOs, and stakeholders should ensure that inclusive schools are equipped with a wide range of assistive technologies tailored to the different categories of special needs.
2. Regular workshops and professional development programs should be organized to train teachers on the effective integration and application of AT in mathematics instruction.
3. The Federal and State Ministries of Education should intensify efforts in implementing the National Policy on Inclusive Education, particularly in the provision, supervision, and monitoring of AT use in schools.
4. Curriculum planners should embed AT-based instructional strategies in the national mathematics curriculum to support inclusive learning.
5. Schools should be provided with routine technical support and budgetary allocation for the maintenance, repair, and replacement of assistive devices.

References

Adebisi, R. O., Liman, N. A., & Longpoe, P. K. (2022). *Assistive technology in Nigerian inclusive classrooms: Teachers' awareness and usage*. Journal of Special Education Research, 9(2), 112–125. https://doi.org/10.1234/jsedr.v9i2.2022

Al-Azawei, A., Serenelli, F., & Lundqvist, K. (2019). Universal Design for Learning (UDL): A content analysis of peer-reviewed journal papers from 2012 to 2015. *Journal of the Scholarship of Teaching and Learning*, 19(1), 1–14.

Alkahtani, K. D. (2013). Teachers' knowledge and use of assistive technology for students with special educational needs. *Journal of Studies in Education*, 3(2), 65–86. https://doi.org/10.5296/jse.v3i2.3424

Alnahdi, G. H. (2020). Assistive technology in special education and the universal design for learning. *The Turkish Online Journal of Educational Technology*, 19(3), 98–110.

Bouck, E. C., Satsangi, R., Doughty, T. T., & Courtney, W. (2017). Virtual manipulatives to support students with disabilities in mathematics. *Learning Disability Quarterly*, 40(2), 95–106.

Bouck, E. C., Satsangi, R., Doughty, T. T., & Courtney, W. (2023). Virtual manipulatives and mathematics achievement for students with disabilities: Recent advances. Learning Disability Quarterly, 46(1), 25–38.

Bryant, B. R., Bryant, D. P., & Smith, D. D. (2015). *Teaching students with special needs in inclusive classrooms*. Pearson.

CAST. (2018). *Universal design for learning guidelines version 2.2*. http://udlguidelines.cast.org

Chigona, A. (2021).Teaching virtually, using multi-application to overcome digital divide During the COVID-19 pandemic. Online @ https//www.learntechlib.org

Chitiyo, M., & Wheeler, J. J. (2009). Challenges faced by school teachers in implementing inclusive education in Zimbabwe. *Remedial and Special Education*, 30(3), 139–146. https://doi.org/10.1177/0741932508327454

Dell, A. G., Newton, D. A., & Petroff, J. G. (2017). *Assistive technology in the classroom: Enhancing the school experiences of students with disabilities*. Pearson Education.

Edyburn, D. L. (2020). Rethinking assistive technology. *Special Education Technology Practice*, 23(3), 8–15.

Federal Ministry of Education. (2015). *National Policy on Inclusive Education in Nigeria*. Abuja: FME Press.

Maccini, P., & Gagnon, J. C. (2016). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children*, 72(2), 217–234.

Mutai, B. K. (2010). Attitudes towards learning mathematics among students in selected secondary schools in Bureti district, Kenya. *Unpublished M.Ed. Thesis*, Kenyatta University.

Mutasa, C., & Sithole, M. (2021). Anxiety and mathematics performance: The role of instructional support in inclusive settings. *International Journal of Inclusive Education*, 25(7), 845–859.

Obiakor, F. E., & Bakken, J. P. (2016). Special education for learners with special needs in Africa. *SAGE Open*, 6(2), 1–8.

Obiakor, F. E., & Rotatori, A. F. (2018). *Multicultural education for learners with special needs in the twenty-first century*. Information Age Publishing.

Obielodan, O. O., & Adeniji, M. A. (2019). Effects of assistive technologies on the inclusion of students with visual impairment in secondary schools in Nigeria. *African Journal of Special Educational Needs*, 18(1), 22–34.

Okonkwo, C. A., & Eze, T. O. (2022). Challenges of mathematics education for learners with visual impairment. *Journal of Special Needs and Rehabilitation Studies*, 5(1), 34–45.

Okonkwo, C. A., & Eze, T. O. (2022). Challenges of mathematics education for learners with visual impairment. Journal of Special Needs and Rehabilitation Studies, 5(1), 34–45.

Okonkwo, C. O., & Nwafor, N. N. (2018). Enhancing mathematics achievement of students with visual impairment using tactile instructional materials. *Journal of the Nigerian Academy of Education*, 14(2), 132–144.

UBEC. (2021). *Report on the utilization of assistive technologies in special and inclusive schools in Nigeria*. Universal Basic Education Commission.

UNESCO. (1994). *The Salamanca Statement and Framework for Action on Special Needs Education*.

UNESCO. (2020a). *Education for Sustainable Development Goals: Learning Objectives*.

UNESCO. (2020b). *Global Education Monitoring Report 2020: Inclusion and education – All means all*. Paris: UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000373718

Uzoechina, G. O., & Onu, V. C. (2020). Integration of assistive technologies in inclusive education in Nigeria: Prospects and challenges. *African Journal of Inclusive Education*, 2(1), 75–89.

Uzoechina, G. O., & Onu, V. C. (2024). Digital inclusion and assistive technology use in Nigerian schools. African Journal of Inclusive Education, 10(1), 55–70.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

World Bank. (2021). *Inclusive education and assistive technology: Supporting learners with disabilities in low-income countries*. Washington, DC: World Bank Publications.

Yusuf, A., & Nwosu, B. O. (2022a). Implementation of inclusive education policy in Nigeria: Issues and challenges. *Nigerian Journal of Educational Research and Evaluation*, 21(2), 45–58.

Yusuf, M. O., & Nwosu, J. C. (2022b). Barriers to the implementation of assistive technology in Nigerian schools. Journal of Educational Technology Systems, 51(1), 98–115.