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Technology as a tool for assisting students with special educational needs to learn and like mathematics and science: a literature review

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Abstract

Students with Special Educational Needs are encouraged to achieve high academic standards in Mathematics and Science education to better understand the natural world, develop life skills, and achieve career success. In this regard, digital technology assists students with disabilities in achieving Mathematics and Science literacy. This article presents a systematic literature review on the role of technology in Science education for students with Special Education Needs. An extensive search in academic databases yielded 24 journal articles from 2006 to 2022. These 24 empirical studies' were reviewed through electronic databases, including Scopus, ERIC, Google Scholar, and Science Direct. The findings demonstrate that using assistive technology in Mathematics and Science education had a major positive impact on students' motivation, attitude, and academic performance. Positive learning outcomes probably depend on how digital technology is used, specifically the capabilities of each unique technological implementation. For evidence-based research designs in digitally supported learning environments for students with Special Education Needs, digital technology and its affordances are recommended, among other quality indicators.

Keywords: Special Education Needs, Mathematics and Science, assistive technology, motivation, attitude, and academic performance

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Introduction

All human beings are born equal, with equal educational rights and needs. Students with Special Educational Needs should be given opportunities to reach their full potential. They should have equal access to education and training opportunities as students without Special Educational Needs, and they shouldn't face any discrimination. Digital technologies are widely available and easily accessible as a result of the development of information technology, allowing for their use in creating new opportunities for students (Cagiltay *et al.*, 2019). It is particularly crucial in the context of Special Education Needs, where teachers' needs, attitudes, competencies, and use of instructional technologies in their classrooms have been largely disregarded when developing computer-supported instructional materials. With the aid of technology, educators can provide Special Education Needs students with a wide range of learning opportunities and methodologies that engage, educate, and support them using various strategies catered to their unique learning styles (AL-Shammari, 2015).

Assistive technology refers to devices and services that are used to increase, maintain, or improve the capabilities of a disabled student (Newton and Dell, 2011). In other words, assistive technology is any item or piece of equipment designed to improve a student's functional capability or assist a student with special educational needs in accessing the general education curriculum. Assistive technologies have played a significant role in today's special education classroom. Teachers should be aware of these assistive technologies so that they can plan lessons and use them to meet the needs of their students in the classroom (Van Laarhoven *et al.*, 2012).

The research showed that students with Special Educational Needs are struggling to learn mathematics compared to other students without it (Akpan and Beard, 2014). For example, Senjam (2019) showed that the majority of mathematics and science relies on visual instruction, so learning math and science concepts is a great challenging task for students with visual impairment and blindness. In addition, Abiatal and Howard (2019) illustrated that sign language is a form of communication for the deaf that is based on visual signs and gestures. Furthermore, learning sign language from textual teaching materials can be difficult. Their difficulties can result in cognitive deficits that harm academic achievement (Abiatal and Howard, 2019). It was found that many students, particularly those with Special Educational, struggle to use visualization as a strategy, which has an impact on their math and science (van Garderen, Scheuermann, and Poch, 2014). However, Assistive technology also allows students with Special Educational Need to participate in a variety of non-academic indoor and outdoor activities (Senjam et al., 2019). Assistive technology emphasizes instructional guides for classroom teachers that would make students with Special Educational Needs benefit as much as possible from

the use of assistive technology tools, whether in the classroom or at home, in order for the technology to make the teaching-learning process enjoyable and effective. It also highlighted the need to select the right technology tools for students with Special Educational Needs to achieve the target goals (Adebisi, Liman, and Longpre, 2015). According to Alkahtani (2013) who found that assistive technology enables students with Special Educational Needs to improve their access to the curriculum and the quality of their learning experience. In this regard, Assistive Technology enhances communication and collaboration and prompts student's engagement in mathematics (Reddy *et al.*, 2021).

Research questions

1. What are the most common technologies used to teach students with special educational need mathematics and science?
2. What is the impact of using technology in teaching students with special educational need mathematics and sciences?
3. What are the perceptions of students with special educational needs towards using technology in teaching and learning mathematics and science?

Significance of the study

This study aims to comprehend the needs and attitudes of special education teachers toward computer-based instructional materials. The results of this study may provide insight into the creation of computer-based instructional materials that specifically cater to the needs of students with special learning needs and their teachers. The effective integration of assistive technology in mathematics and science instruction will improve the outcomes of students with specific learning disabilities in mathematics and science, which will increase their access to the general education curriculum. The outcome of this study will provide important information for educators to choose assistive technology for students with a specific learning disability in mathematics and science that addresses the student's area of identified need, supports the instructional goal, and supports student outcome. In addition, teachers of mathematics and science can arm themselves with the necessary pedagogical tools needed to instruct a student with special educational needs and be more aware of the necessity of giving students access to the most recent assistive technology for teaching and learning mathematics.

The results of this study will assist curriculum designers in incorporating assistive technology into science and math lessons. Furthermore, understanding the function of assistive technology will help parents of students with special educational needs assist in supplying the proper assistive technology

to special schools in mathematics and science. The findings might influence the government and policy-makers to prioritize spending on new assistive technology tools and teacher training on integrating assistive technology in teaching mathematics and science.

Methodology

ERIC, SCOPUS, Science Direct, and Google Scholar were searched with the following keywords and combinations: visual, hearing, and physical impairment, intellectual disabilities, assistive technology, teaching and learning, mathematics, chemistry, biology, and physics. The studies chosen should be empirical and published in peer-reviewed journals in English between 2006 and 2022.

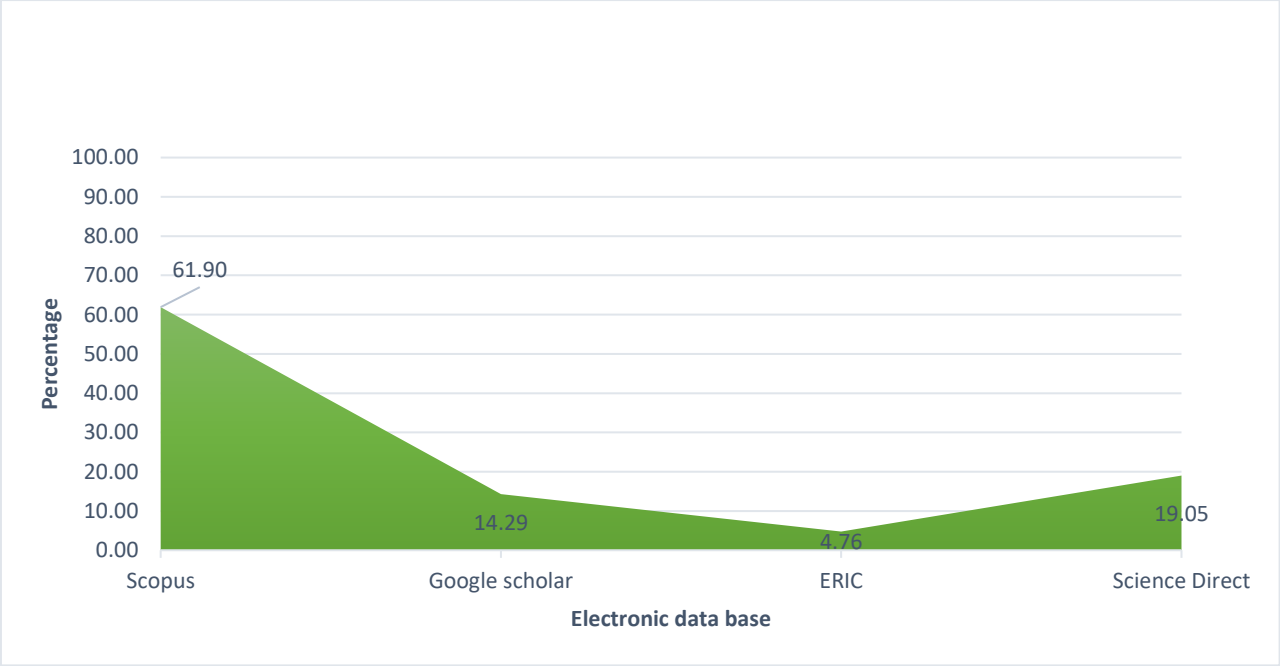

Figure 1. Selected articles from electronic databases

A total of 169 articles were initially downloaded by the authors from Scopus (83), Google Scholar (26), ERIC (23), and Science Direct (24), and these were the sources that initially returned records for articles. Based on the exclusion criteria, 72 articles were excluded based on the fact that they are duplicates, published before 2006, and not related to the objective of the study. Further screening was conducted, and only 24 articles based on the inclusion criteria remained with only articles published between 2006-2022 related to the objectives of the study, written in English, and support intervention.

Results and Discussion

Table 1 summarizes the impact of using technology in mathematics and science teaching and learning for students with Special Education needs. It demonstrates the technology used and its utility in motivation, attitude, and academic performance. The information presented in table 1 was chosen from 24 articles that were selected.

Table 1. Information about the selected studies

Assigned Numbers for the Articles	Journals publisher	Authors & Year	Research Method	Educational context	Type of special educational need	Technology used	Conclusion
1.	Disability and Rehabilitation: Assistive Technology	(Senjam et al., 2019)	Quantitative	- Mathematics	Blind and visually impaired students	- Abacus - Talking calculator - tactile geometric kits - Braille ruler - Braille compass - Braille cube - Raised line graph - Braille protractor	Conceptual understanding of mathematics
				- Science (Biology)	Blind and visually impaired students	- Tactile maps - Sciences tactile diagram	Motivation of students
2.	SAICSIT conference (SAICSIT'19)	(Abiatal and Howard, 2019)	Mixed	Mathematics	Deaf	Computer-assisted instruction	Increase student's academic performance and provide a visual representation of the concept
3.	REVISTA SAN GREGORIO	(Baglama & Yucesoy, 2019)	Quantitative	Mathematics	Intellectual disabilities	Computer-assisted video	Positive attitude
4.	EURASIA Journal of Mathematics Science and Technology Education	(Silman, Yaratan and Karanfiller, 2017)	Qualitative	Mathematics	-Blind and Visual impairment	- Reading device - Audio map - I-pad - Cubes - Trays	Students satisfaction
5.	Education and Information Technologies	(Nsabayezu, Iyamuremye and	Mixed	Science (chemistry)	- Hearing impairment - Blind and visual impairment	- Video - Audio - Simulation	Increase motivation and

		Urengejeho, 2022)					sharing of resources
6.	Journal of Chemical Education	(Gomes et al., 2020)	Quantitative	Science (Physics	Blind and Visual impairment	Arduino	- Low-cost Arduino for effective teaching of physics - Teacher satisfaction
7.	The Electronic Journal of e-Learning	(Mon, Yap and Ahmad, 2021)	Quantitative	Science (physics)	Blind and visually impaired	Hepatics and odor device	Encourage teaching and learning activities.
8.	Assistive Technology Outcomes and Benefits	(Cary, A *et al.*, 2006)	Mixed	Science (chemistry)	Blind and visually impaired	Submersible Audible light sensor (SALS)	Visualization of chemical reaction
9.	Journal of Chemical Education	(Costa and Fernandes, 2019)	Quantitative	Science (chemistry)	Blind and visually impaired	Arduino Uno	Effective teaching and learning of PH
10.	IGI Global	(Gomes & Mensah, 2015)	Mixed	Science (biology)	Intellectual disabilities	iBook	- Increase student performance in biology - Students satisfaction
11.	Journal of Chemical Education	(Neely, 2007)	Quantitative	Science (biology, geology, physics, and chemistry)	Visual and physical impairment	- Braille typewriters - Assemblage - Labware	- The use of laboratory equipment was improved - Students motivation.
12.	Disability and Rehabilitation: Assistive Technology	(Maćkowski *et al.*, 2022)	Mixed	Mathematics	Visual	Multimedia	Increase of motivation

13.	Disability and Rehabilitation: Assistive Technology	(Encarnação *et al.*, 2017)	Mixed	Mathematics and science	Motor and speech impairment	Robot	- Increase performance - Positive perception
14.	Disability and Rehabilitation: Assistive Technology	(Farhan and Razmak, 2020)	Mixed	Mathematics and science	- Visual impairment - Hearing needs	E-learning system	Increase motivation
15.	Journal of Applied Mathematics	(Amiripour Parvaneh Amiripour Yahoo Com *et al.*, 2011)	Quantitative	Mathematics	Dyscalculia	Math Explorer software	Increase problem-solving skills
16.	Sustainability	(Rodríguez-Cano *et al.*, 2022)	Quantitative	Mathematics	Intellectual disabilities	Audiovisual simulation	Students' performance in mathematics.
17.	International Journal of Research and Scientific Innovation	(Wairimu, Chomba and Awori, 2018)	Mixed	Mathematics	Visual impairment	- Thermoforms - Braille writers - Adapted computer systems - Braille transcribers	Effective teaching mathematics
18.	Rural Special Education Quarterly	(Taylor, Lohmann and Kappel, 2022)	Quantitative	Science (Biology)	Autism	Multimedia	Students' motivation and engagement
19.	Hammill Institute on Disabilities	(Knight *et al.*, 2014)	Mixed	Science (Biology)	Visual impairment	E-text	Increase students' performance and motivation
20.	Australian Journal of Learning Difficulties	(Polat *et al.*, 2019)	Mixed	Science (Biology)	Learning disabilities Intellectual disabilities	Tangible mobile application	Increases performance
21.	Learning Disability Quarterly	(Marino *et al.*, 2014)	Quantitative	Science (Biology and chemistry)	- Intellectual disabilities	Video game	High level of engagement

22.	Learning Disability Quarterly	(King-sears *et al.*, 2015)	Mixed	Science (Chemistry)	- Intellectual disabilities - emotional disturbance - Speech Language Impairment	Multimedia	Stimulate critical thinking
23.	European Journal of Contemporary Education	(Fatikhova *et al.*, 2017)	Mixed	Science (Biology)	Intellectual disabilities	3D graphics with multimedia elements on IWB	Immediate positive results, students not able to recall terms, increased interest
24.	Learning Disabilities: A Contemporary Journal	(Vanuitert *et al.*, 2020)	Quantitative	Science (Biology)	- Intellectual disabilities - Speech-language Impairment	Multimedia	Positive learning outcomes.

Impact of using technology for assisting students with Special Education Need on students' motivation, attitude and academic performance

Table 1 above showed that technology is important in teaching and learning mathematics and science for the student with special education needs. The study conducted by Senjam et al. (2019) on the use of assistive technology for students with visual disabilities from 250 students selected randomly from 10 blind schools in Delhi where different assistive technology in mathematics and sciences such as Abacus, talking calculator, tactile geometric kits, tactile maps and sciences tactile diagram showed that use of assistive technology stimulate students conceptual understanding of mathematics and encourage students to learn science, especially biology mainly animal and human anatomy. This was also supported by Abiatal and Howard (2019) on Constructivist Assistive Technology in a Mathematics Classroom for the deaf in the Namibian Primary School; the quantitative results implied that the use of constructivist digital assistive technology improved the students' mathematical performance while qualitative data showed that constructive assistive technology encourages collaboration, exploration, self-assessment, learning from errors, seeking knowledge independently, self-regulating, self-reflecting, foster metacognitive thinking of the mathematical concept.

In this regard, the study conducted by Baglama and Yucesoy (2019) on the using technology to improve the attitudes of students with intellectual disabilities towards mathematics in a special education and rehabilitation center in North Cyprus showed that the use of instructional video stimulates intellectual disability students attitudes in mathematics, self-confidence, and conceptual understanding of mathematics. The association's teaching and learning processes were made easier by the technology used to assist those who are blind or visually impaired. The visually impaired could communicate more effectively and use various technological tools in their lessons, including audio maps, iPads, cubes, and trays Silman et al., (2017).

The research conducted by Amiripour Parvaneh Amiripour Yahoo Com et al. (2011) on the use of The Effects of Assistive Technology on Increasing Capacity of Mathematical Problem Solving in Dyscalculia Students where two basic addition and subtraction operations are taught through mathematical software called Math Explorer software, the ANOVA results showed that there was statistical significance in the mean performance of students using Math explorer compared to the control group. This indicated that the use of "Math explore" as assistive technology problem-solving skill was enhanced. This is in line with Nsabayezu, Iyamuremye, and Urengejeho (2022), who found that computer-based learning to enhance chemistry instruction in the inclusive classroom in the form of audio, simulation, and video encourages students to understand chemistry concepts, including the periodic table, water pollution, effective ways of waste management, and categories of chemical reactions increase student students conceptual understanding and inspire student in chemistry lessons. Use An Arduino-Based Talking Calorimeter for Inclusive Lab Activities connected to headphones for the simultaneous operation of several users is effective for blind students and prompt students construction of knowledge in chemistry (Gomes et al., 2020). In this line, the use of 3D-based haptic, audio, and olfactory edutainment application for visually and hearing impaired students encourages students to engage in learning activities in a virtual environment and helps learn forces, vibrations, or motions (Mon, Yap, and Ahmad, 2021). The study conducted by Cary, A et al. (2006) also

confirmed it: Seeing Chemistry through Sound: A Submersible Audible Light Sensor (SALS) for Observing Chemical Reactions for Students Who Are Blind or Visually Impaired found that The SALS offers an accessible medium that enables these students to experience chemical reactions in the laboratory in a way that is similar to their sighted peers and also it enables students with blindness and visual impairments to observe chemical reactions in real-time.

Designing Arduino sensing PH for supporting blind and visually impaired students in teaching and learning laboratory activities showed that Arduino increased the participation of visually impaired students in chemistry laboratory classes. Furthermore, via the designed device, visually impaired students can take charge of their learning about pH, a crucial chemistry concept (Costa and Fernandes, 2019). The use of assistive technology in the form of audio in teaching the Nervous System, Circulatory System, and Respiratory System for Students with Learning Differences in Middle School Science Classes showed that there it improves students' scientific literacy and performance as it was supported by strong statistical evidence from pretest and posttest with ANCOVA analysis (Gomes & Mensah, 2015).

With reference to the research conducted by Neely (2007) on the use of Technology and Other Assistive Strategies To Aid Students with Disabilities in Performing science Lab Tasks for students with physical and visual disabilities indicated that the use of technology where a variety of strategies were used to increase lab task completion rates, including the use of assistive technology and changes to the physical design of the lab setup, illustrated that the majority of students displayed growth in skill and increased comfort with lab tools. The utilization of multimedia computer-aided math learning as a tool to assess and increase motivation in learning math by visually impaired students by using multimedia for visually impaired students found that a multimedia is an effective tool as it increases students' performance and motivation (Maćkowski *et al.*, 2022). This also supported the research conducted by Encarnação et al. (2017) on the use of assistive robots to promote inclusive education in mathematics and science showed that the use of robots as assistive technology positively impacts students' performance and motivation, and satisfaction in mathematics and science. The use of an e-learning system in inclusive schools increases students' motivation of students with visual and hearing impairments (Farhan and Razmak, 2020).

The implementation of educational technology as a Supporting tool for Students with Specific Learning Difficulties. The use of audio-visual as educational technology tool prompts student conceptual understanding and motivation of students with intellectual disabilities in mathematics. The study was conducted by Rodríguez-Cano *et al.* (2022). Assistive technology in the inclusive classroom significantly impacts performance and attitude in teaching mathematics (Wairimu, Chomba, and Awori, 2018). The use of technology to support students suffering from autism increases their engagement and motivation in science education, especially in Biology (Taylor, Lohmann, and Kappel, 2022).

Authors' reflection on the use of assistive technology for supporting students with Special Educational Need

Students with Special Educational Needs can succeed in math and science classes if they have access to the class's content and activities when teachers use effective teaching strategies that adhere to the

inclusionary principle where all students, including those with disabilities, benefit from access to education with their fellow students. Inclusion classroom strategies include having students with special educational needs work with partners or in small groups where each student can contribute based on his or her strengths.

Some students with Special Educational Needs may need accommodations to participate fully in lab science activities. Numerous assistive technologies are available to help people with mobility, sensory, and other disabilities gain access. Instruments that provide auditory or tactile feedback may be useful for students who are blind or have significant visual impairments. The position and height of lab tables and equipment may need to be adjusted or modified for students with physical disabilities. Computer simulations of laboratory experiments may be useful to students in some cases.

The use of assistive technology benefits students in two ways: it can help them learn how to complete a task, and it can help them get around a challenging area. For instance, a student is navigating a challenging area when they choose to listen to a digital version of a book. However, if the student concentrates while highlighted words are read aloud on the computer screen, they can pick up new words.

Students with learning disabilities can benefit from laptops and tablets because they are portable and lightweight. Taking notes on a laptop or other computerized device (like an iPad) can help students who have trouble writing legibly and increase the quantity and quality of their notes. Students with learning disabilities can benefit from this nonjudgmental computerized drill and practice because computer-assisted instruction offers immediate and dynamic feedback. Students with learning disabilities can benefit greatly from computer-assisted instruction when it comes to performing math drills. Students who practiced math skills with computer-assisted instruction were better able to memorize math facts and had a more favorable attitude toward math than students who did not use computer-assisted instruction. Mathematical assistive technology (AT) tools are made to assist those who have trouble organizing, aligning, and writing down math problems on paper. Users can more easily set up and perform basic math calculations with visual and/or audio support.

For many young people, utilizing technology to improve learning is a successful strategy. Additionally, when allowed to work around their disabilities using their strengths, students with LD frequently succeed more (challenges). The best elements of both of these techniques are combined in AT tools. The school should make it available if the student needs to use assistive technology in the home to receive a FAPE. For instance, a student should be permitted to bring an assistive technology device home if they require it to complete homework assignments.

Teachers who work with children with disabilities now have more potent and effective tools at their disposal, thanks to technology. These tools allow teachers to adapt instruction to meet the wide range of learning needs of each student while also providing new and more effective methods of learning. Teachers are using computers to deliver and facilitate learning beyond drill and practice, create settings that support learning, and guarantee improved and equitable learning environments for all students.

Improvements in sensor controls allow for the control of mobility equipment, such as electric wheelchairs, with subtle motor movements, enabling independent movement around the school and community. A portion of a monitor can be made large enough for people with vision impairments to see using text and graphics enhancement software. A digital voice synthesizer can read the text for someone who is blind. Amplification devices can pick up an FM signal from a microphone on a teacher's lapel or filter out background noise for people with hearing impairments.

The goal of inclusive education, a cutting-edge educational idea, is to encourage all students to participate in the teaching and learning process. Effective inclusive practices continue to face obstacles, even though many nations have revised their educational systems to encourage the learning of all students in the same classroom. Studies examining only students' perspectives on resource availability are few and far between in this discourse. Children with disabilities can participate in academic activities thanks to the advancement of assistive technologies. However, full inclusion would necessitate the presence of another adult in the classroom and planning for how to deal with the fact that it takes the kids longer to complete the tasks.

Conclusion, implications, and future research

The current study confirms that digital technology contributes to the acquisition of academic skills in mathematics and science subjects in special education through its numerous implementations of technological tools such as multimedia, virtual reality, and augmented reality, as well as its various applications such as e-texts, games, and simulations. Our findings emphasize the importance of a pedagogical approach combined with the appropriate use of digital technology, which frequently results in positive learning outcomes. Even when simple technological implementations are chosen, student-centered models combined with meaningful learning activities supported by learning affordances of technologies contribute to acquiring academic skills in mathematics and science. Thus, the study implies educational policy-makers, educators, and stakeholders integrate technology to support students with special educational needs to learn and like mathematics and science. The pedagogical benefits of digital technology in science instruction for students with disabilities are currently the subject of empirical studies. Future studies must include interventions that consider the capabilities of the technologies being used, a careful analysis of the research design, and should conjure one or more items in relation to the integration of recent technology in a digital world.

Conflict of interest

Authors declare no conflict of interest.

Data availability statement

Data are available in public (institutional, general, or subject-specific) repository that issues datasets with DOIs.

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