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Education and inclusive technologies for students with neurodevelopmental disorders: A systematic scoping review

Educazione e tecnologie per l'inclusione per studenti con disturbi del neurosviluppo: una scoping review sistematica

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ABSTRACT This scoping review examines the utilization of inclusive technologies for students with neurodevelopmental disorders after the COVID-19 pandemic. It classifies technologies into six categories: task-specific software, virtual and augmented reality, video modeling, hardware equipment, learning environments, and computer-mediated communication systems for interactions with peers and tutors occurring online. Findings indicate that most interventions focus on academic skills, with limited emphasis on fostering social inclusion or peer interaction. Intellectual and developmental disabilities were the most represented conditions, followed by learning disabilities and Attention-deficit/hyperactivity disorder. Gaps include the need for more holistic pedagogical frameworks and insufficient research on emotional well-being and long-term impact, highlighting the need for future exploration.

KEYWORDS Scoping Review; Inclusive Technology; Students with Disabilities; Secondary Education; Social Inclusion.

SOMMARIO Questa scoping review esplora l'uso delle tecnologie inclusive per gli studenti con disturbi del neurosviluppo considerando il periodo post-pandemico. Le tecnologie vengono classificate in sei categorie: task-specific software, realtà virtuale e aumentata, video modeling, attrezzature hardware, software e applicazioni per la comunicazione/interazione online. I risultati mostrano che la maggior parte degli interventi si concentra sulle competenze accademiche, con una limitata attenzione all'inclusione sociale o all'interazione tra pari. Le disabilità intellettive e dello sviluppo sono le condizioni più rappresentate, seguite dai disturbi dell'apprendimento e dal disturbo da deficit di attenzione/iperattività. Le lacune individuate includono la necessità di quadri pedagogici più olistici e la carenza di ricerche sul benessere emotivo e sugli impatti a lungo termine, evidenziando la necessità di ulteriori approfondimenti.

PAROLE CHIAVE Scoping Review; Tecnologie per l'Inclusione; Studenti con Disabilità; Educazione Secondaria; Inclusione Sociale.

1. Introduction

The COVID-19 pandemic, which emerged in 2020, profoundly changed numerous aspects of our lives. Education was significantly affected among the sectors (Zhao, 2020). The closure of schools and other educational facilities necessitated a complete reorganization of teaching and learning (Pokhrel & Chhetri, 2021; Ratten, 2023; Tinterri et al., 2021).

The pandemic prompted substantial shifts in how lessons were conducted and courses delivered (Cone et al., 2022; Zancajo et al., 2022). Online teaching platforms, virtual learning environments, and various internet-based technological solutions were adopted globally, often in an improvised manner that was not always optimal or well-prepared (Li, 2022). This sudden transition introduced unprecedented challenges for students and teachers, particularly in terms of adapting to new technologies and ensuring educational continuity (Manca et al., 2022; Oliveira et al., 2021).

The impact was particularly acute for students with neurodevelopmental disorders (Dvorsky et al., 2023). The pandemic significantly reduced opportunities for social interactions, participation, and direct access to support from specialists such as special education teachers, educators, and other professionals in inclusive education (Colombo & Santagati, 2022; Kouroupa et al., 2022; Lipkin & Crepeau-Hobson, 2023). Pre-existing challenges for these students, such as difficulties in traditional classroom settings and the scarcity of adequately digitized materials, became even more pronounced during the health crisis. The closure of physical schools also exacerbated disparities, highlighting the lack of readiness to address the specific needs of students with disabilities in remote learning contexts.

In response to these challenges, various solutions were explored and adopted to provide remote support. Online learning tools and communication platforms were developed or expanded to ensure educational continuity. Numerous technologies, including apps, software, digital platforms, and assistive technologies, were implemented to address the learning needs of students with and without disabilities. Innovative approaches, such as social robotics, video modeling, and virtual reality, have emerged as promising tools to enhance engagement and accessibility during and after the pandemic (Aymerich-Franch & Ferrer, 2022; Hughes et al., 2022; Kerdvibulvech & Chang, 2022).

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

While the COVID-19 pandemic served as a significant catalyst for the development and adoption of educational technologies, the aim of this review is not to assess the direct effects of the pandemic. Instead, we consider the post-pandemic educational context as a pivotal opportunity to examine how inclusive technologies have been explored, implemented, and studied to support students with neurodevelopmental disorders in both academic and social dimensions of learning.

In particular, this scoping review aims to map the educational possibilities explored and studied for students with neurodevelopmental disorders during and after the pandemic. Specifically, the review focuses on identifying digital educational solutions and assistive technologies that are utilized or proposed to address the needs of this group of learners within the school. In particular, our perspective is that of inclusive education (de Bruin, 2019; Downing & Peckham-Hardin, 2007; Lascioli, 2014, 2021; Lindsay, 2003; Pavri & Luftig, 2001), which seeks to ensure that all students, regardless of their abilities or disabilities, can participate fully in educational activities. In fact, this review is grounded in the Italian model of inclusive education, which is characterized by the full integration of students with disabilities into mainstream classrooms. In Italy, special schools have been progressively phased out since the 1970s, and legislation mandates that all students, regardless of disability, attend regular schools with appropriate support measures. This approach emphasizes the right to inclusive, equitable, and quality education for all, supported by individualized educational plans, co-teaching models, and the presence of specialized support teachers within general education settings. By adopting this perspective, our review interprets the literature through a lens that prioritizes dismantling segregated educational environments and promoting systemic inclusion.

Accordingly, we aimed to investigate whether inclusive technologies were utilized for instructional or educational purposes, or whether they were employed to enhance the environment's comfort and accessibility, promote peer interaction, and facilitate the social inclusion of students with neurodevelopmental disorders within their educational context. This dual focus allows us to understand how technologies contribute to academic progress and the broader goal of inclusion in school communities. By systematically analyzing the literature, this review provides a comprehensive understanding of the opportunities and challenges that emerged, highlighting effective practices and identifying gaps in educational solutions for students with neurodevelopmental disorders. This scoping review builds upon and updates a systematic review concluded in 2020, which focused on examining studies that evaluated the impact of assistive technology on the inclusion of students with disabilities (Fernández-Batanero et al., 2022). A significant added value of this review is that it encompasses a substantial period following the pandemic and therefore includes the results of post-COVID research.

2. Materials and Methods

2.1. Methodological and Theoretical Perspectives

This scoping review systematically maps assistive technologies for inclusion, specifically addressing the educational needs of students with neurodevelopmental disorders. A scoping review methodology is justified by its ability to encompass a wide range of evidence, enabling an in-depth understanding of the multifaceted aspects of technology use in special education. The flexible inclusion criteria inherent in this methodology make it particularly suitable for

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

exploring this specific domain within the educational context (Arksey & O'Malley, 2005; Levac et al., 2010). The review question was formulated using the Population, Concept, and Context (PCC) framework (Pollock et al., 2023), which guided our exploration of the following research question: "How are technologies for educating students with neurodevelopmental disorders within secondary education programs employed, studied, and evaluated?".

To support a coherent analytical approach, we developed a threefold categorization of neurodevelopmental disorders that reflects recurring patterns observed across the studies. This framework groups conditions into learning disabilities (LD), intellectual and developmental disabilities (IDD), and attention-deficit/hyperactivity disorder (ADHD). While not intended as a clinical classification, this categorization captures educationally relevant distinctions in how technologies are applied to support different types of needs. LD includes conditions that specifically impact the acquisition and use of academic skills despite average or above-average intellectual functioning. The following conditions are categorized under LD: dyslexia, dysgraphia, dyscalculia, and specific learning disabilities, a general category embracing difficulties in one or more academic areas (e.g., reading, writing, math) not attributed to intellectual, sensory, or environmental factors. IDD is broader and encompasses significant limitations in intellectual functioning, adaptive behavior, and sensory processing. It includes limitations in intellectual functioning and adaptive behaviors, autism spectrum disorder, Down syndrome, developmental delays, and visual and hearing impairments. Finally, ADHD is a neurodevelopmental disorder marked by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with academic, social, and behavioral functioning.

To support the analysis, we developed a classification of technologies into six categories: task-specific software, virtual and augmented reality (VR/AR), video modeling, hardware equipment, learning environments, and computer-mediated communication systems.

This categorization emerged inductively from the technological typologies reported across the included studies. While all categories technically fall under the broader umbrella of software, we distinguish between task-specific software—such as applications designed to support reading, writing, or communication—and learning environments, which refer to integrated platforms (e.g., learning management systems or multi-component intervention tools) that combine content delivery, student monitoring, and interaction. This categorization aims to reflect the variety of functionalities and pedagogical uses observed and to provide a coherent framework for analyzing how different technologies support academic, behavioral, and social goals in inclusive education.

Task-specific software encompasses computer programs and mobile applications designed to address specific educational tasks or assistive needs. These tools are typically designed for focused, single function use to support students with neurodevelopmental disorders in particular areas of learning or communication. Examples include:

- Text-to-speech software assists students with reading difficulties by converting written text into spoken words.
- Word prediction software supports writing by suggesting words based on the user's input.
- Mathematics tools, such as visual calculators or symbolic manipulators, used to aid comprehension and problem-solving.
- Assistive apps, including augmentative and alternative communication (AAC) applications designed to facilitate expression for non-verbal or minimally verbal students.

VR/AR utilizes immersive and interactive tools that enable students to engage with virtual or augmented environments, enhancing learning and skill acquisition, including life skill simulations.

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

Video modeling encompasses technologies that use video demonstrations to teach skills or behaviors. Students observe modeled tasks or behaviors and replicate them in real-life contexts.

We refer to hardware equipment as physical tools and devices designed to support accessibility, mobility, and learning for students with sensory, physical, or cognitive disabilities (e.g., adaptive keyboards, screen readers, braille displays, 3D printers, smartwatches).

Learning environments refer to integrated systems or bundled tools that provide a comprehensive solution for teaching and learning (like learning management systems or gamified learning platforms).

Finally, computer-mediated communication systems, which utilize tools that facilitate online interactions, involve technologies that enable collaboration and social relations in virtual spaces. These tools became particularly relevant during the COVID-19 pandemic.

This review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)-ScR guidelines to ensure transparency and replicability in the research process (Tricco et al., 2018).

2.2. Search Strategy

To identify research studies addressing these questions, we searched three electronic databases (ERIC, Scopus, and PsycINFO) between February 21 and May 18, 2024. The search focused on materials published in English from 2020 onwards. The surge in educational technology use since the onset of COVID-19 makes 2020 a suitable starting point. This scoping review also updates a 2020 systematic review on the impact of assistive technology for the inclusion of students with disabilities (Fernández-Batanero et al., 2022).

The search strategy was structured around two dimensions of key terms:

1) Technologies and approaches: virtual reality, social robotics, assistive technology, video modeling, augmentative and alternative communication, apps, inclusive technology, artificial intelligence, educational platforms, accessibility, and educational technology.
2) The target population includes people with special educational needs, youth with disabilities, adolescents with disabilities, students with disabilities, and others with disabilities.

These key terms were conceptualized to address the review questions and served as inclusion criteria for the analyzed studies. Table 1 provides a detailed account of the search strategy, including the terms used and database-specific configurations.

Table 1. Search strategy (PCC)

Population	Students and teachers	student* OR teacher*	#1
Concept	Technology for inclusion and access	"educative tech*" OR "educational tech*" OR "education tech*" OR "techn*" OR accessibility OR "virtual reality" OR "education platform" OR "social robotics" OR "video modeling" OR "augmentative and alternative communication" OR "inclusive technology" OR "artificial intelligence"	#2

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

Concept	Special needs	"special need*" OR "disabilit*" OR "student* with disabilit*"	#3
Context 1	Middle school	"Middle School*"	#4
Context 2	High school	"High School*"	#5
Final search strategy: #1 AND #2 AND #3 AND (#4 OR #5)			

2.3. Inclusion and Exclusion Criteria

We included studies involving teachers, support teachers, and students with disabilities/ neurodevelopmental disorders aged 11 to 21, encompassing also individuals with sensory disabilities and physical impairments. The inclusion criteria focused on studies examining the impact of technologies on this population. Studies using quantitative, qualitative, and mixed-methods approaches were considered. Additionally, we limited the review to peer-reviewed studies published in the English language.

We excluded conference abstracts, expert opinions, non-research articles, and book chapters, as these sources often lack the methodological transparency and depth necessary to contribute robustly to the evidence base. Ongoing studies and protocol articles were also excluded to focus on completed research with available results. Although systematic reviews were not included in the data extraction and synthesis, as per the scoping review methodology (Ghirotto, 2020), which is designed to map primary empirical evidence, they were consulted during the initial framing of the study to ensure that our review provides an updated and original contribution to the existing body of research.

2.4. Study Selection Process

Two authors (IT and EG) independently screened the titles and abstracts of retrieved articles. Any discrepancies were discussed with a third researcher (LG) until a consensus was reached. The same procedure was applied to the full-text screening phase.

2.5. Data Extraction

We systematically extracted data from the selected studies using predefined criteria, including:

- First author.
- Year of publication.
- Country.
- Aim(s) of the study.
- Skills targeted.
- Educational setting(s).
- Educational level.
- Study population.
- Type of disability/neurodevelopmental disorders or condition addressed (categorized into three macro-areas: ADHD, IDD, or LD).
- Technologies employed or evaluated (task-specific software, VR/AR, video modeling, hardware equipment, learning environments, and computer-mediated communication systems).

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

- Study design.
- Data collection methods.
- Data analysis methods.
- Summary of findings.

2.6. Data Organization (Data Charting)

The extracted data were organized in a structured format through a systematic data charting process. Descriptive statistics, including frequencies and percentages, were used to summarize nominal data. Initially, data extraction followed a deductive approach guided by the criteria for data extraction. Subsequently, during the data charting phase, an inductive approach was adopted to thematically analyze the data and identify patterns, themes, and discrepancies across the studies (Braun & Clarke, 2021).

IT and LG reviewed the extracted data in detail to ensure a thorough understanding of the content. The data were then systematically coded, capturing predefined categories and emerging insights. This process combined deductive coding (focusing on expected categories) with inductive coding (capturing new elements that arose during analysis). The integration of these two approaches ensured a cohesive narrative and comprehensive insights.

3. Analysis

We employed both quantitative and qualitative approaches to analyze the data:

- Quantitative analysis was utilized to identify patterns and contingencies within the data. This included exploring the relationships between educational levels, types of disabilities/ neurodevelopmental disorders, and technological categories. Additionally, the quantitative analysis enabled us to identify trends in the adoption of specific technologies for various types of neurodevelopmental disorders and educational levels (e.g., middle school, secondary, and post-secondary).
- Qualitative analysis was conducted using the findings and descriptions presented in the selected articles. The thematic analysis highlighted the relationships and nuances involved in implementing technologies, the challenges they presented, and their perceived impact. This approach provided a deeper understanding of the context in which technologies were used, revealing discrepancies or gaps in inclusivity and accessibility, particularly for underserved groups.

All authors engaged in collaborative discussions throughout the analysis phase to validate results, ensure consistency, and synthesize findings into a cohesive narrative. This mixed-methods approach enabled a robust examination of the use of inclusive technologies in education for students with neurodevelopmental disorders, highlighting both successes and areas requiring further research and development.

4. Results

4.1. Search Results

The total number of retrieved documents was 852. After removing duplicates and conducting an analytical review of the titles and abstracts, 108 papers were selected for full-text

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

screening. Of these, 64 articles met the inclusion criteria. Figure 1 shows the PRISMA flowchart (Page et al., 2021). The studies were predominantly conducted in the United States and Turkey. The United States accounted for a significant portion of the sample, representing 70.3% of the cases. Other countries had much smaller representations, with most contributing only a single case each.

The total number of student participants included in the studies is 1,355. Of these, 34.1% (n = 462) were middle school students (aged 11–14), 42.6% (n = 577) were from secondary or post-secondary settings (aged 14–21), and the remaining participants were involved in studies spanning both educational levels (n = 316). The distribution of conditions across educational levels reveals distinct patterns in the studied populations. Middle school students with LD represent the majority, accounting for 50.9% of the population (235/462 students), followed closely by students with IDD at 48.1% (222 students). Students with ADHD are far less represented, comprising only 1.1% (5 students). In studies spanning mixed educational levels, LD remains the most common condition at 41.1% (130 students), followed by IDD at 35.1% (111 students) and ADHD at 23.7% (75 students). At the secondary level, most students have IDD, making up 76.9% of the population (443 students), while LD accounts for the remaining 23.1% (133 students). No cases of ADHD are reported at this level. Finally, in post-secondary education, only one student with IDD was identified.

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

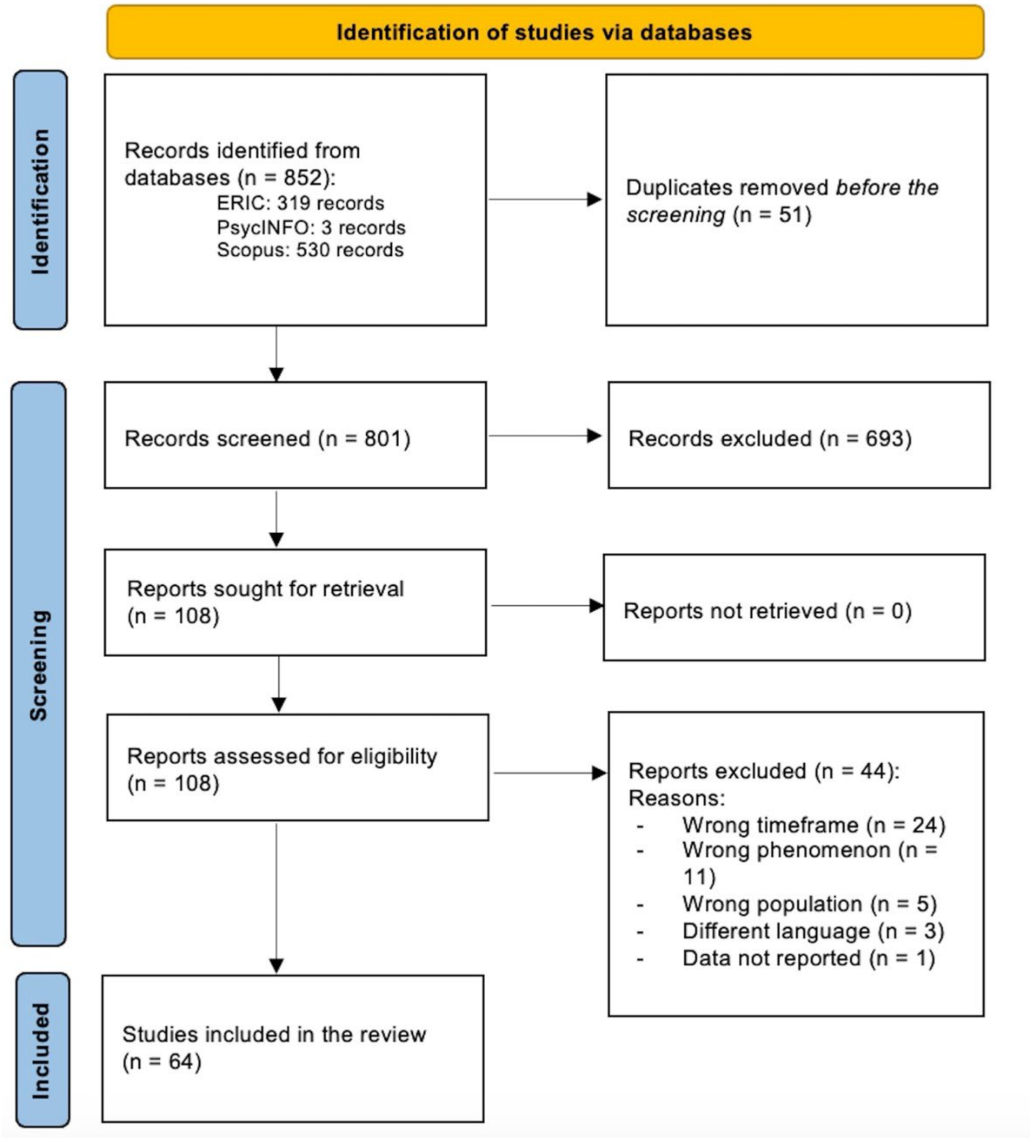

Figure 1. PRISMA flowchart.

4.2. Studies Characteristics

Table 2 provides an outline of the main characteristics. The complete data extraction table and a list of the included studies are available as supplemental materials (Appendix 1[1] and 2[2]).

Regarding countries, we considered the nation where the research took place. As to study design, over half of the included studies employed single-case designs, reflecting a strong emphasis on individualized, in-depth intervention analysis typical in special education and assistive technology research. Only a small proportion used quasi-experimental or mixed

[1] The appendix 1 is available here: https://shorturl.at/Rn7SU
[2] The appendix 2 is available here: https://shorturl.at/GXtx0

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

methods designs. A significant portion of the studies involved small sample sizes. Specifically, nearly 40% of the studies had fewer than 10 participants.

Table 2. Outline of studies' characteristics (N=64, 100%)

Characteristic			n(%)
Countries	Canada		1 (1.6)
	France		1 (1.6)
	Greece		1 (1.6)
	India		1 (1.6)
	Israel		1 (1.6)
	Jordan		1 (1.6)
	Malaysia		1 (1.6)
	Mexico		1 (1.6)
	Romania		1 (1.6)
	Saudi Arabia		1 (1.6)
	Sweden		1 (1.6)
	Taiwan		1 (1.6)
	Turkey		7 (10.9)
	USA		45 (70.3)
Skills	Academic		45 (70.3)
	Social		18 (28.1)
	Technical		1 (1.6)
Educational level	Middle schools		32 (50)
	Secondary/Post-secondary		28 (43.8)
	Mixed		4 (6.3)
Condition	IDD		48 (75)
	LD		14 (21.9)
	ADHD		2 (3.1)
Technologies	Task-specific software		20 (31.3)
	AR/VR		16 (25)
	Video modeling		13 (20.3)
	Hardware equipment		8 (12.5)
	Learning environments		4 (6.3)
	Computer-mediated communication systems		3 (4.7)
Study design	Qualitative		4 (6.3)
	Mixed methods		2 (3.1)
	Quantitative Single-Case Designs	Single case with multiple probe designs	20 (31.3)
		Multiple baselines across participants	7 (10.9)
		Alternating treatment single-case designs	4 (6.3)
		ABAB (reversal/withdrawal) designs	3 (4.7)
		AB single-case designs	3 (4.7)
		Other single-case variations (e.g., multiple probes across skills/behaviors)	7 (10.9)
	Quantitative Quasi-	Pretest–posttest control group designs	2 (3.1)
		Non-equivalent comparison group designs	2 (3.1)

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

Characteristic		n(%)
Experimental Designs	One-group pretest-posttest designs	2 (3.1)
	Quasi-experimental pre-post designs with active control	1 (1.6)
Other quantitative	Cross-sectional survey design	1 (1.6)
	Single-arm, noncontrolled hybrid effectiveness-implementation trial	1 (1.6)
	Descriptive case study with one-group pretest-posttest design	1 (1.6)
	Usability study designs	1 (1.6)
	Not clearly stated	(4.7)

4.3. Trends in the Literature

Among the studies analyzed, inclusive technologies were primarily used to support academic skills (70.3%) and, to a lesser extent, social skills (28.1%). Notably, only 11 out of 64 studies (17%) explicitly identified inclusion as a core objective, focusing on enhancing peer interactions, fostering active classroom participation, and preparing students for integration into broader social and community contexts. The remaining studies, while potentially contributing indirectly to inclusive practices, tended to prioritize individual learning outcomes—such as content mastery, task execution, or behavioral improvement—without explicitly framing these goals within an inclusive pedagogical perspective. This reflects a broader trend in the literature, where inclusion is often assumed rather than critically examined or intentionally pursued as a guiding framework for technology-mediated interventions.

Table 3 presents the distribution of the studies across school levels and types of skills, highlighting that studies in middle schools primarily focus on academic skills and preparation, likely because this educational stage is foundational.

Table 3. Skills/education levels.

	Middle N (%)	Mixed N (%)	Secondary/Post-secondary N (%)	Tot. N (%)
Academic Skills	28 (43.7)	3 (4.7)	14 (21.9)	**45 (70.3)**
Social Skills	4 (6.3)		14 (21.9)	**18 (28.1)**
Technical Skills		1 (1.6)		**1 (1.6)**
Tot.	**32 (50)**	**4 (6.3)**	**28 (43.7)**	**64 (100)**

Regarding the type of neurodevelopmental disorders, the trend of technology solutions adopted was focused on IDD (75%) and LD (21.9%), with only two studies targeting ADHD (see Figure 2).

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

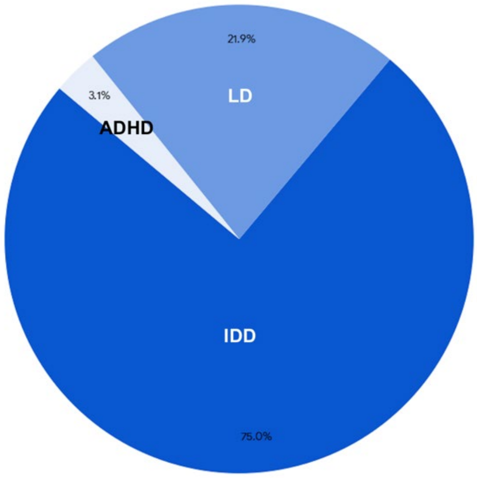

Figure 2. Conditions.

Considering the more commonly used technological categories, the leading tools are task-specific software (31.3%), AR/VR (25.0%), and video modeling (20.3%) (see Figure 3).

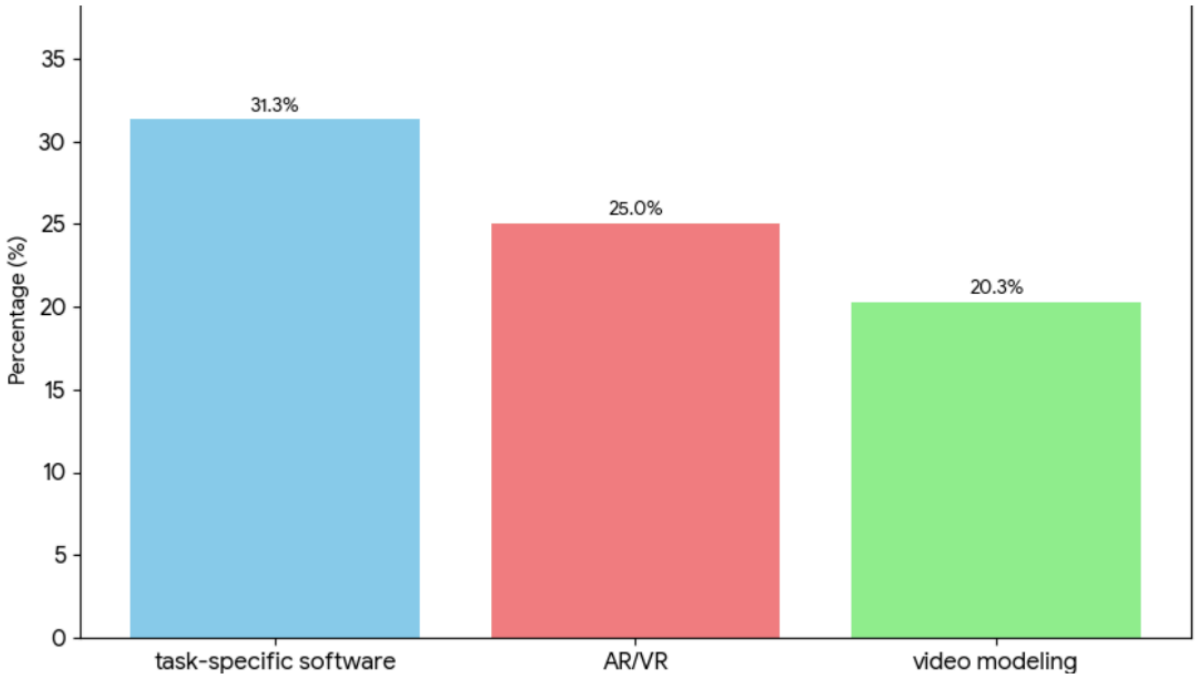

Figure 3. Most used technologies.

Additionally, an in-depth analysis of the contingency between skills and technological categories (see Table 4) revealed that software is primarily utilized for academic skills (75%) and augmented and virtual reality (81.3%). In comparison, video modeling (46.2%) and learning environments are primarily employed for social skills (50%).

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

Table 4. Contingency between skills and technological categories.

			AR/VR	Learning environ ments	Hardware equipment	Computer-mediated communic ation systems	Task-specific software	Video modeli ng	Tot.
Skills	Academic	Count	13	2	8	0	15	7	**45**
		%	28.9%	4.4%	17.8%	0.0%	33.3%	15.6%	**100.0%**
	Social	Count	3	2	0	2	5	6	**18**
		%	16.7%	11.1%	0.0%	11.1%	27.8%	33.3%	**100.0%**
	Technical	Count	0	0	0	1	0	0	**1**
		%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	**100.0%**
Tot.		Count	**16**	**4**	**8**	**3**	**20**	**13**	**64**
		%	**25.0%**	**6.3%**	**12.5%**	**4.7%**	**31.3%**	**20.3%**	**100.0%**

Regarding descriptive statistics about the relationship between condition and technological categories (see Figure 4), video modeling and specialized equipment are commonly utilized for students with ADHD. For students with IDD, the most frequently used technologies include AR/VR, task-specific software, and video modeling. For students with LD, task-specific software is the most commonly used tool.

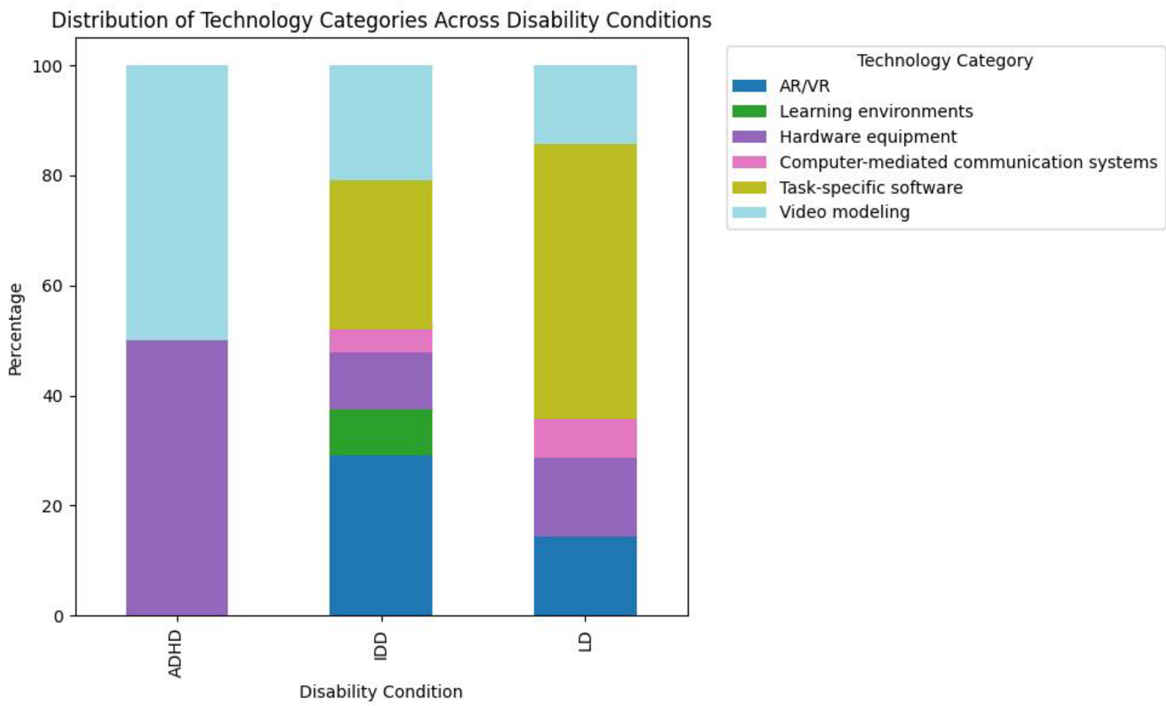

Figure 4. Technology type per conditions.

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

4.4. Qualitative Analysis Findings

4.4.1. Effects of the technology described in the included articles

Multiple studies demonstrate that well-designed intervention packages, such as explicit instructional sequences or virtual models, increase students' accuracy and enhance their skills. For instance, systematic teaching approaches tailored to students' needs significantly improved academic and practical performance.

A second trend across the studies concerns the efficacy of various teaching strategies, particularly those incorporating techniques such as video modeling and AR/VR. The studies' evidence indicates that these methods effectively teach practical skills and facilitate the comprehension of complex content. For example, students with ASD demonstrated positive outcomes when acquiring daily living skills through video modeling. Similarly, AR and virtual simulations enhanced the learning process, enabling students to grasp abstract or challenging concepts more effectively.

A fundamental aspect emerging from the analysis is students' ability to generalize and retain the skills they acquire through educational interventions. The studies reviewed indicate that effective teaching strategies often result in immediate improvements that are sustained over time, and students can transfer these skills to different contexts.

4.4.2. Academic Skills and Learning Outcomes

Many studies focused on improving academic competencies across various domains, such as mathematics and science, reading, and writing. As to mathematics skills, the review highlights that virtual manipulatives were found as effective as concrete ones in teaching algebra and arithmetic skills to students with neurodevelopmental disorders. Intervention packages involving visual aids (e.g., virtual number lines, Cuisenaire® Rods) and explicit instruction increased accuracy and independence in solving mathematical problems (e.g., addition, subtraction, multiplication, division). AR applications improved the understanding of STEM content, including physics and biology. It has been documented that augmented reality helped students retain knowledge of animal features and develop positive attitudes toward science lessons. 3D printed materials and haptic technologies supported complex STEM learning.

As to reading and writing, technology-based graphic organizers (TBGO) and self-regulated learning strategies enhanced persuasive writing quality and generalization of skills. Text-to-speech technologies supported reading and comprehension but were less effective than human readers for some students. Keyword mnemonic interventions improved vocabulary acquisition in biology for students with learning disabilities (LD).

4.4.3. Daily Living Skills and Functional Abilities

Several studies targeted life skills crucial for independence, especially for students with ID and autism spectrum disorders (ASD). Video modeling effectively taught daily living skills such as resume preparation, leisure activities, and Automated Teller Machine (ATM) use. Augmented reality gaming supported task completion, such as navigating automated systems. iPad-based instructional methods improved participation in leisure activities for students with multiple disabilities.

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

4.4.4. Behavioral and Social Skills

Technologies aimed at improving social behaviors and engagement within the classroom and beyond by behavioral interventions (for instance, technology-aided check-in/check-out interventions increased adaptive skills and student engagement and mobile technologies like Google Classroom and WhatsApp enabled communication and task completion for students learning English as a second language); social inclusion (social networks supported by assistive technologies enabled students with ASD and ID to accumulate bonding and bridging social capital, though interactions among groups remained limited; Talking Mats and similar tools gave students with communicative difficulties the ability to express their opinions reliably); engagement (VR-based exergaming increased physical activity levels, while animations improved reasoning and memory capacity; digital response cards enhanced active engagement and on-task behavior during group activities).

4.4.5. Employment Readiness and Pre-Vocational Training

A smaller subset of studies emphasized skills relevant to future employment. Virtual reality job interview training (VR-JIT) was utilized to prepare students with special needs for transition services and enhance employment outcomes. Animation-based video modeling supported the work-specific acquisition of social skills for individuals with IDD.

4.4.6. Perceptions, Attitudes, and Emotional Well-Being

Some studies, mainly qualitative, explored the impact of technologies on students' emotional well-being and attitudes toward learning:

- Participants reported blended learning environments as positive experiences, fostering satisfaction with learning.
- Augmented reality applications created engaging and motivating environments, enhancing positive attitudes toward science lessons.
- Social validity questionnaires revealed that students enjoyed using digital materials, reporting greater engagement and satisfaction.

5. Discussion

This scoping review highlights several notable trends and gaps in the literature on inclusive technologies for students with neurodevelopmental disorders. A key observation is the geographical concentration of studies, with a significant majority originating from the United States. This reflects the active role of U.S.-based institutions, but also reveals a lack of European contributions, which limits the global applicability of the findings and underscores the need for more diverse, cross-cultural research.

Many studies were conducted in countries where special schools or segregated settings remain common, reflecting educational systems where full inclusion is not yet standard (Dwyer, 2023; Taub & Foster, 2020). This contrasts with the Italian model, which informed our perspective and is based on full integration within mainstream classrooms (Andreoli et al., 2024; Lascioli, 2021). As a result, what is labeled “inclusive technology” may serve different purposes across contexts—supporting systemic inclusion in integrated systems or functioning

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as specialized support in segregated ones. This conceptual ambiguity highlights the need for a more context-sensitive understanding of inclusion in international research.

Moreover, most interventions focused on academic skills (70.3%), with limited attention to social inclusion (28.1%), and only 17% explicitly identified inclusion as a core objective. This emphasis likely reflects the structural realities of the educational systems in which the studies were conducted. In segregated or partially inclusive settings, the focus tends to be on individual performance, while opportunities for peer interaction and broader inclusion are limited. While these environments are valuable for piloting interventions, they may not reflect the realities of inclusive classrooms where students with disabilities learn alongside their peers. This raises questions about the scalability and applicability of these technologies in mainstream settings, where inclusion and participation are essential goals (Chambers, 2020). These findings suggest that macro-level educational structures significantly shape the design, goals, and outcomes of technology-based interventions (Dwyer, 2023).

Another critical note concerns the small number of participants in many of the included studies conducted with experimental design. While single-case experimental designs are effective for examining individualized interventions, they often involve only a small number of participants, making it challenging to generalize findings to broader populations. This issue underscores the need for larger-scale studies with diverse samples to strengthen the evidence base and provide actionable insights across various educational contexts and disability groups. Moreover, the presence of unclear designs and other uncategorized formats suggests a need for improved methodological transparency in reporting.

While it is impossible to generalize the quantitative effects derived from the studies included in this scoping review, the emerging themes provide valuable insights. The findings demonstrate that when the opportunity to use inclusive technologies is provided (Desmond et al., 2018), there are functional relationships between well-structured educational interventions and improved student outcomes. This highlights the crucial importance of developing targeted interventions that are both evidence-based and adaptable to the individual needs of each student. Educators can achieve meaningful progress by implementing such tailored approaches, particularly for students requiring additional support (Cranmer, 2020).

Concerning academic skills, the studies indicate that technology-mediated methods effectively teach practical skills and facilitate the understanding of complex content. Technologies such as augmented reality (AR), video modeling, and task-specific software applications were shown to support the mastery of subjects like mathematics, science, and reading by making abstract concepts more tangible and accessible. This reinforces the role of technology as a powerful tool in bridging academic gaps for students with disabilities (Kiru et al., 2018).

However, the most significant contribution of these technologies, particularly in fostering inclusion, is their impact on student engagement (Henrie et al., 2015) and behavior. Many studies reported that students felt more motivated and actively participated in lessons when assistive technologies or interactive approaches were used. For instance, digital tools and gamified learning environments improved on-task behavior and engagement (McNicholl et al., 2021). Moreover, these methods fostered a positive classroom climate (Badr & Asmar, 2021; Goagoses et al., 2024) where students felt valued, involved, and emotionally supported in their learning journey. Such findings highlight the potential of engaging instructional methods to enhance knowledge acquisition and promote behavioral and emotional well-being in educational settings.

A key takeaway is the importance of student-centered practices, where students' voices, preferences, and needs are actively integrated into the educational process (Fernández-Cerero

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et al., 2024; McNicholl et al., 2021). Evidence from the studies reveals that students with learning difficulties are more motivated and engaged when they are given opportunities to express their opinions and shape their learning experiences. This approach fosters greater responsibility and ownership of learning while enhancing self-esteem and confidence. By creating a collaborative and responsive learning environment, educators can offer meaningful opportunities for students to thrive academically and emotionally (Fernández-Batanero et al., 2022).

Technologies such as augmented reality, video modeling, and virtual reality simulations have transformative potential for improving accessibility and academic achievement and for creating an engaging and inclusive classroom climate for all students, regardless of disability (McNicholl et al., 2021). Therefore, technology-mediated teaching methods should prioritize active participation, motivation, and behavioral engagement, which are essential for building supportive and inclusive educational settings (McNicholl et al., 2021).

In planning educational experiences within the classroom, incorporating student voices (Kotera et al., 2021; Tsatsou, 2020) into the learning process helps build confidence, ownership, and a sense of belonging (Mohammadi Zenouzagh et al., 2023). While technologies have a proven impact on academic skills, their non-specific effects—such as improving classroom climate, fostering peer interactions, and promoting a sense of inclusion—should not be overlooked. Educators should strive to utilize technologies to achieve academic goals and enhance the broader social and emotional aspects of education. By doing so, technology fosters equitable and inclusive learning environments where all students can thrive and succeed.

5.1. Implications for Future Research

Future research must adopt a comprehensive theoretical perspective that informs the use of technology for inclusion, extending beyond the development of academic skills to encompass a holistic approach to inclusion. This perspective should position technology as an integral component of a broader pedagogical framework to promote social inclusion, classroom participation, and integration into societal systems (Brown et al., 2019). Among the studies, inclusive technologies were mainly found to support academic skills (70.3%) and, to a lesser extent, social skills (28.1%). Only 11 of 64 studies (17%) explicitly aimed to include participants, focusing on peer interactions, participation, and social integration. Others prioritized individual outcomes, such as content mastery and behavioral improvements, often assuming inclusion rather than actively pursuing it as a framework. This limited focus highlights a significant gap in literature, suggesting that inclusive technologies are usually approached narrowly, without sufficient emphasis on their potential to support meaningful inclusion within the classroom and beyond.

Future studies should prioritize investigating how technology can be integrated into inclusive pedagogical designs that account for the diverse needs of students with neurodevelopmental disorders, as well as exploring inclusive technologies within general education classrooms to better align with the principles of inclusive education.

This includes exploring how digital tools can facilitate peer interactions, create welcoming environments, and foster a sense of belonging in educational and social contexts (McNicholl et al., 2021). By broadening the scope of research, we can ensure that technology is a transformative element in building inclusive education systems that address the full spectrum of students' needs.

In terms of methodological limitations evidenced by this scoping review, future studies should spotlight:

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- More extensive and more diverse samples to improve the generalizability of findings.
- Carefully designed research methods, such as randomized controlled trials, to minimize bias and ensure causal inferences.
- Transparent and detailed reporting of data analysis procedures to enhance the reliability of conclusions.

By overcoming these challenges, research can better inform evidence-based practices and policies that improve the accessibility and effectiveness of educational technologies for students with neurodevelopmental disorders.

5.2. Limitations

While this scoping review provides valuable insights into using inclusive technologies for students with neurodevelopmental disorders, it has limitations. One notable limitation is the reliance on published peer-reviewed studies, which may introduce a publication bias. Studies with negative or inconclusive results are often underrepresented in literature, potentially skewing the findings toward more favorable outcomes. Additionally, this review included only articles published in English, which may have excluded relevant studies conducted in non-English-speaking contexts, limiting the generalizability of the results to diverse cultural and educational settings. Another limitation is the variability of methodologies and reporting standards across the included studies. While valuable for individualized interventions, the predominance of single-case experimental designs and small sample sizes limits the generalizability of findings to broader populations. Furthermore, the diversity of technologies studied, ranging from simple software applications to complex AR/VR systems, makes it challenging to draw definitive conclusions about the relative effectiveness of specific tools. The lack of standardized outcome measures across studies also poses a challenge for synthesizing and comparing results, as studies often focus on different skills, educational goals, and types of disabilities.

Finally, this review primarily focused on the educational context, potentially overlooking the broader societal and systemic factors that influence the adoption and efficacy of inclusive technologies. For example, the included studies should have addressed the role of school infrastructure, teacher training (Fernández-Batanero et al., 2022), and policy support in shaping the effectiveness of these technologies. These factors are critical to understanding how inclusive technologies can be implemented sustainably and equitably. Future reviews could expand on these dimensions to provide a more comprehensive understanding of the systemic factors shaping the use of inclusive technologies.

5.3. Conclusion

This scoping review aligns with the growing demand for systematic, adaptable, and exploratory approaches in educational technology research. By focusing on middle and secondary school students with neurodevelopmental disorders, the review highlights a critical population often overlooked in broader studies of educational technology.

By classifying technologies into six distinct categories—task-specific software, VR/AR, video modeling, hardware equipment, learning environments, and computer-mediated communication systems—and mapping them across three main neurodevelopmental disorder groups (LD, IDD, and ADHD), we identified both prevailing trends and critical gaps in the current research body.

Accepted Manuscript Online. DOI: 10.17471/2499-4324/1503

One of the most significant insights is that most studies focus predominantly on academic outcomes, with limited attention given to the role of technology in promoting social inclusion, peer interaction, or emotional well-being. Technologies such as video modeling, AR/VR, and digital platforms have demonstrated promising effects on student engagement and behavior, yet these aspects remain underexplored as primary research goals.

Furthermore, the geographical concentration of the research—dominated by studies from the United States—reveals a lack of diversity in educational contexts. European research is particularly underrepresented, which limits the generalizability of the findings and underscores the need for more internationally diverse investigations.

Another gap concerns the small sample sizes and the frequent use of single-case experimental designs, which, although valuable for individualized interventions, restrict the scalability of findings. In addition, many interventions were tested in specialized rather than inclusive settings, raising questions about their applicability in mainstream classrooms.

A final, yet crucial, insight is the limited presence of pedagogical frameworks that guide the integration of these technologies. While the tools themselves are innovative, their educational potential could be significantly enhanced by embedding them within inclusive teaching strategies that account for student voice, classroom participation, and broader socio-educational goals.

Future research should therefore aim to (1) expand the focus beyond academic metrics to include social and emotional dimensions of inclusion; (2) test technologies in real-world, inclusive classrooms; (3) adopt larger and more diverse samples; and (4) develop theoretical frameworks that integrate inclusive technologies into holistic pedagogical designs. Doing so will help shift the field from isolated technological applications to more meaningful, sustained, and equitable educational practices.

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