# Can Social Robots Support Learners with SLDs? An Overview Across Dyslexia, Dysgraphia, and Dyscalculia*

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## Abstract

Specific Learning Disorders (SLDs), including dyslexia, dysgraphia, and dyscalculia, affect a significant portion of the school-age population and pose substantial challenges to academic development and emotional well-being. Traditional interventions often rely on repetitive and demotivating exercises, underscoring the need for more engaging and personalized educational strategies. In recent years, social robots have emerged as promising tools in special education, offering new opportunities to support students with SLDs through emotionally responsive, interactive learning experiences. This work presents an overview of the current state of the art concerning the use of social robots in interventions targeting SLDs. Focusing on studies that address dyslexia, dysgraphia, and dyscalculia, the analysis examines applied methodologies, levels of integration within educational environments, and evidence of effectiveness. By identifying existing trends and research gaps, this work aims to inform future developments in the field and promote more inclusive, motivating, and technologically enriched learning practices.

## Keywords

Social Robot, Specific Learning Disorders, Dyslexia, Dysgraphia, Dyscalculia

## 1. Introduction

According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), Specific Learning Disorders (SLDs) define a single diagnostic category that includes persistent difficulties in the acquisition and effective use of academic skills, which typically become evident during the school-age years [1]. Three types of SLDs can be identified and can be further characterized by detailed descriptors and classified according to severity levels: deficits in reading referred to as dyslexia; writing deficits, known as dysgraphia; and mathematics deficits, referred to as dyscalculia [2].

*Dyslexia*, affecting 80% of all those identified as learning-disabled [3], is the most common SLD that affects individuals' ability to read with accuracy and fluency, and it often impairs the development of spelling [4]. Closely related to dyslexia is *dysgraphia* [5], which can manifest as difficulty with writing at various levels, including illegible handwriting, slow writing speed, spelling difficulties, and issues with syntax and written composition [6]. Instead, *dyscalculia*, which has a prevalence of 3–7% of all children, adolescents, and adults [7], is defined as difficulty acquiring basic arithmetic skills [8], such as estimating quantities, counts, and simple computational tasks [9].

In Italy, the Ministry of Education and Merit[1] reports that 5.7% of students enrolled in primary, middle, and high schools were diagnosed with SLDs in the 2021/2022 school year, increasing to 6% in 2022/2023. Among the various forms of SLDs, dyslexia is the most prevalent, affecting 3.0% of the total student population, followed by dysgraphia (1.9%) and dyscalculia (1.8%), although these percentages do not represent the number of unique individuals, as a single individual may exhibit comorbid disorders [10][11]. Overall, these disorders call for targeted educational interventions and compensatory strategies that can foster inclusion, alleviate school-related stress, and enhance students' motivation to learn.

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[1]https://www.mim.gov.it/web/guest/-/i-principali-dati-relativi-agli-alunni-con-dsa

In this context, recent years have witnessed the emergence of innovative technologies in special education, with growing research interest in how these tools can be integrated into everyday classroom practice to support students [12][13]. Among them, social robots are gaining increasing attention as promising tools in both educational and rehabilitative settings, across a variety of tasks and different groups of learners [14][15]. Students with SLDs appear to be particularly responsive to robot-mediated teaching activities, especially in terms of attention and engagement, as these interactions help create a positive and supportive learning environment [16], while also enabling emotionally responsive and socially meaningful engagement, transforming classroom practices, supporting personalized learning, and improving outcomes [17, 18].

This work aims to provide an updated overview of the current state of the art on the use of social robots to support children with SLDs. The analysis focuses on the main applications documented in the literature across dyslexia, dysgraphia, and dyscalculia. It examines the methodologies adopted, the integration of robots into educational settings, and the available evidence regarding their effectiveness.

The paper is structured as follows: Section 2 describes the followed methodology, Section 3 shows the state of the art, Section 4 presents a discussion and the limitations of the results obtained. Finally, Section 5 concludes the paper and presents future work.

## 2. Methodology

This paper examines a selection of recent studies addressing the use of social robots to support learners with SLDs. It does not follow rigid selection protocols, but it seeks to offer a broad, descriptive, and cross-cutting analysis of the existing literature, with particular attention to studies that address SLDs as a whole, as well as those focused specifically on dyslexia, dysgraphia, and dyscalculia.

Literature search is conducted across three academic databases Google Scholar[2], Scopus[3], and the ACM Digital Library[4]. The search employed the following basic keyword combination from SLDs and social robots, adapted to the syntax and search constraints of each database:

**Search Keyword Combination**

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("social robot") AND ("dyslexia" OR "dysgraphia" OR "dyscalculia" OR
"SLD" OR "Specific Learning Disorder")
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A time filter was applied to include only publications from 2020 to 2025, in order to focus on the most recent and relevant contributions. At the end of the search process, 326 results were retrieved from Google Scholar, 14 from Scopus, and 56 from the ACM Digital Library.

A subsequent screening phase is conducted considering: (a) the removal of duplicate entries across databases, (b) the exclusion of studies not published in English, (c) the exclusion of conference reviews, theses, and non–peer-reviewed publications, (d) the inclusion of only studies explicitly focused on SLDs (in general and especially on dyslexia, dysgraphia, or dyscalculia) (e) the inclusion of studies that clearly employed social robots as the main technological component.

Following this second phase, a total of 18 studies were identified and retained for analysis, as shown in Table 1. These were then organized according to the specific type of learning disorder addressed: 9 studies focused on dysgraphia, 6 on dyslexia, and 1 on dyscalculia. Additionally, 2 studies addressed SLDs more broadly, without targeting a specific subtype.

## 3. State of the Art

A recent body of research has demonstrated the potential of social robots to support the cognitive, emotional, and motivational needs of learners with SLDs. These interventions are no longer limited to

[2]https://scholar.google.com/
[3]https://www.scopus.com/
[4]https://dl.acm.org/

**Table 1**
List of selected studies.

| Reference | Year | Database | Type of SLD |
|---|---|---|---|
| [19] | 2021 | Google Scholar/Scopus | Dysgraphia |
| [20] | 2023 | Google Scholar/Scopus | Dyslexia |
| [21] | 2022 | Google Scholar/Scopus | SLDs |
| [22] | 2023 | Google Scholar/Scopus | Dyslexia |
| [23] | 2023 | Google Scholar | Dysgraphia |
| [24] | 2024 | Google Scholar/Scopus | Dysgraphia |
| [25] | 2023 | Google Scholar/Scopus | Dyslexia |
| [26] | 2025 | Google Scholar | Dyslexia |
| [27] | 2023 | Google Scholar | Dysgraphia |
| [28] | 2023 | Google Scholar | Dyslexia |
| [29] | 2021 | Google Scholar | Dyslexia |
| [30] | 2021 | Google Scholar | Dyslexia/Dysgraphia |
| [31] | 2022 | Google Scholar/Scopus | Dysgraphia |
| [32] | 2020 | Google Scholar | Dysgraphia |
| [33] | 2023 | Google Scholar/ACM | Dysgraphia |
| [34] | 2022 | Google Scholar | Dysgraphia |
| [35] | 2023 | Google Scholar | Dysgraphia |
| [36] | 2025 | Google Scholar | Dyscalculia |

exploratory prototypes or experimental setups: many have been implemented in structured educational and therapeutic environments, often in close collaboration with teachers, therapists, and caregivers.

For instance, Papadopoulou et al. [21] conducted a randomized controlled trial showing that a robot-assisted intervention, delivered by the humanoid robot NAO in collaboration with a special educator, was as effective as traditional instruction in improving reading fluency and phonological awareness in children with SLDs. The study also highlighted the feasibility and positive reception of such interventions among both students and families. These findings are expanded upon in the case study by Estévez et al. [30], in which the NAO robot was used as an assistant in speech therapy sessions with children aged 9 to 12 years diagnosed with language disorders, dyslexia, dysgraphia, and a specific language impairment. Although not a randomized controlled trial, this study offers a rich and in-depth analysis of children's behavior, motivation, and emotional responses within a real therapeutic setting.

Taken together, these findings reinforce the potential of social robotics as a tool for inclusive education, which can address the varied cognitive and linguistic challenges. By providing adaptive, engaging, and emotionally supportive interactions, robots can function as both pedagogical partners and therapeutic aides. The following sections delve into how social robotics has been specifically applied to three major forms of Specific Learning Disorders: dyscalculia, dyslexia, and dysgraphia.

### 3.1. Dyslexia

The potential of social robots as assistive technologies for supporting children and young adults with dyslexia in educational contexts aims not only to facilitate language acquisition but also engagement and inclusion through emotionally responsive and interactive learning experiences.

A key contribution in this area is offered by Suneesh et al [20], who developed a Child-Robot Interaction (CRI) framework adapted to children with dyslexia. The system combines four learning modalities (auditory, visual, kinaesthetic, and reading/writing) into interactive games delivered through the NAO robot's multimodal interface. Activities such as Sound and Read, Spelling, Picture Memory, and Spatial are designed to enhance skills like phonological awareness, memory, and spatial reasoning. Grounded in educational models such as the VARK learning styles and multisensory instruction, the framework also addresses emotional aspects by incorporating praise, repetition at the child's pace, and tactile interaction. Though still in its pilot phase, the study lays an important baseline for future longitudinal and co-designed interventions.

In a follow-up study, the same authors proposed a more structured play-based framework that extends their initial CRI approach by embedding the four learning modalities within a game sequence inspired by multisensory teaching strategies [28]. The framework emphasises the therapeutic aspect of child-robot interaction, aiming not only to reinforce linguistic abilities but also to enhance motivation and self-confidence. The robot assumes a co-player role, actively engaging the child in shared tasks that combine cognitive stimulation with affective feedback, highlighting the potential of social robots as both pedagogical and emotional support agents.

Complementary to this work, Shahab et al. [22] propose a hybrid approach that integrates a tablet-based lexicon application with a custom social robot, Taban, to facilitate vocabulary acquisition in children. The tablet handles user input, while the robot provides multimodal feedback, verbal, visual, and physical, offering a solution to common speech recognition limitations in CRI systems. The study involves both dyslexic and typically developing children, enabling a comparative analysis that highlights distinct performance profiles and high levels of user acceptance. Grounded in the phonological deficit theory of dyslexia, the system specifically targets skills such as phoneme recognition, working memory, and visual-verbal association, exemplifying a theory-driven design.

Building on this work, a second study by the same authors [25] explores a Virtual Reality (VR) Serious Game featuring a virtual avatar of the Taban robot. Designed to improve phonological awareness in dyslexic children, the system guides users through interactive VR exercises using the Oculus Quest headset. The study involved 19 children (6 dyslexic), and results showed that typically developing children significantly outperformed their dyslexic peers across all tasks, confirming the system's diagnostic potential. Both groups reported high enjoyment and engagement, indicating that the V2R (Vulnerability to Resilience) approach is both effective and well-accepted, particularly in contexts where physical robots are not available.

Fung et al. [26] present a comparative study of two robot platforms, Kebbi and Minibo, within a language learning program involving both dyslexic and non-dyslexic students. The robots differ in embodiment and interaction richness: Kebbi offers expressive gestures and visual feedback, while Minibo adopts a more minimal design. Results show that dyslexic students engaged more with Kebbi, suggesting that multimodal and physically embodied features are particularly effective for this group. Conversely, non-dyslexic students responded well even to the simpler Minibo interface. These findings underscore the need for adaptive robot design tailored to different learner profiles, challenging the notion of universal solutions in educational robotics.

A more technical and engagement-focused perspective is offered by Papakostas et al. [29]. Using multimodal audio-visual data and an AdaBoost ensemble classifier, their system achieved over 93% accuracy in distinguishing engaged from disengaged states. While not limited to dyslexia, the study includes it within a broader range of learning difficulties. Notably, the work introduces a closed-loop interaction model, enabling adaptive robot behavior based on engagement levels, and emphasizes the need for scenario-specific calibration. These findings support the development of responsive and personalised educational robots capable of maintaining learner attention and preventing disengagement.

### 3.2. Dysgraphia

Traditional approaches to dysgraphia assessment and treatment have typically relied on repetitive pen-and-paper exercises that many children find demotivating or stressful. As an alternative, interdisciplinary research has begun to investigate the use of social robots to enhance engagement and support learning.

One of the most comprehensive efforts in this direction is the study conducted by Gouraguine et al. [35], who proposed a humanoid robot-based framework for classifying students according to the type and severity of their dysgraphia. In their paper, NAO robot interacts with parents through a structured questionnaire aimed at identifying the core symptoms of each dysgraphia subtype (lexical, phonological, spatial, dyslexic, and motor). The classification system, based on a matrix of symptom correlations validated by domain experts, uses a decision tree model to assign each child to a specific category and severity level. The results demonstrated that 92.3% of the robot-generated classifications matched those of human specialists, suggesting that social robots can provide efficient and consistent support in the early identification of learning disorders.

In a complementary study by the same group [23], the diagnostic process was approached from a data-centric perspective. Through a robot-mediated handwriting activity involving over 170 children aged 6 to 12, the researchers collected a dataset of more than 11,000 images of handwritten digits. These samples were used to train a Convolutional Neural Network (CNN) that achieved a diagnostic accuracy of 91%, confirming the feasibility of using AI to detect dysgraphia based solely on writing patterns captured during CRI.

Other researchers have focused on therapeutic and educational uses of social robots in the context of handwriting rehabilitation. For example, the longitudinal single-case study conducted by Gargot et al. [19] involved a 10-year-old boy diagnosed with multiple neurodevelopmental disorders, including ADHD, developmental coordination disorder, and severe dysgraphia. In this intervention, the child engaged in a "learning-by-teaching" scenario, where he taught a NAO robot how to write by correcting its attempts via a tablet interface. Over the course of 20 weekly sessions, the child's motivation was restored, avoidance behaviors decreased, and significant improvements in posture and handwriting quality were observed.

Following this direction, Tozadore et al. [34] developed a system that integrates QTrobot with the Dynamilis handwriting assessment app. The system provides real-time analysis of multiple handwriting features, including pressure, speed, tilt, and static form, and uses this data to personalize the child's training sessions through adaptive feedback and serious games. Tested in a pilot study with 31 children, the system demonstrated both technical robustness and sustained user engagement. The authors further extended their work through the iReCheck project [33], introducing a modular architecture that includes posture recognition via RGB-D cameras, user modeling via finite state machines, and decision-making based on behavior trees. The system can operate autonomously or under the supervision of a therapist and is designed for long-term use in both classroom and clinical environments.

Recognizing the need to support therapists in their use of these systems, Zou et al. [31] proposed a Wizard-of-Oz interface that enables therapists to trigger robot behaviors manually through a structured library of predefined actions. This interface allows for context-sensitive interventions, such as praise, error correction, and motivational feedback, and was evaluated through simulated sessions with 15 therapists from different professional backgrounds. While the system was found to be usable and effective, the authors noted that the complexity of the interface could limit its scalability, prompting further iterations that prioritize usability and semi-autonomous behavior suggestion. Building on this principle of co-design, the R2C3 project, proposed by the same authors [24], involved both therapists and children with neurodevelopmental disorders in the iterative development of a robot-assisted rehabilitation framework. The project confirmed the value of robots in promoting productive engagement during therapy, with caregivers using the system primarily to deliver positive reinforcement, encourage reflection, and scaffold error management.

Beyond screen-based interactions, several studies have emphasized the importance of tangible and multisensory feedback in handwriting rehabilitation. Guneysu Ozgur et al. [32] developed a series of activities using haptically enabled Cellulo robots, designed to support children with attention and visuomotor coordination difficulties. Their iterative studies, conducted across public schools and therapy centers, highlighted the benefits of robot-assisted activities that combine kinesthetic learning with collaborative play. Children were encouraged to engage in shape tracing and guessing games, all of which targeted specific cognitive and motor dimensions of handwriting. The system was adaptable in terms of duration, frequency, and content, and showed measurable gains in letter representation quality.

Lastly, another study by Gouraguine et al. [27] highlighted how robots can play an instructional role in classroom settings. In this work, the NAO robot presented a handwriting lesson to students and then guided them through a structured task designed to capture digit-writing samples. These were subsequently analyzed using a CNN classifier, which achieved 75% diagnostic accuracy. The system included multiple interaction modalities, verbal prompts, physical gestures, and time management instructions, making it a self-contained instructional and diagnostic tool.

### 3.3. Dyscalculia

The literature analysis revealed a noteworthy finding: using our defined search string, only one study was identified that directly addresses dyscalculia through the combined use of educational robotics and game-based learning. To date, the only contribution explicitly tackling this issue is the work by Stasolla et al. [36].

This pilot study was conducted across three lower secondary school classes and proposed an integrated, innovative approach, on the one hand, employing educational robots (Ozobot Evo and SAM Labs) for hands-on and experiential activities, and on the other, incorporating game-based dynamics to enhance motivation and learning. The sample included students with diverse cognitive profiles, including five formally diagnosed with dyscalculia, who were distributed between an experimental group (robotics + gamification) and a control group (traditional instruction).

The findings showed significant improvements in the experimental group in both numerical accuracy (from 52% to 75%) and motivation (mean scores of 4.6 out of 5), along with a marked reduction in math-related anxiety. The study also highlighted gains in participation, operational autonomy, and peer collaboration, key dimensions for educational strategies targeting students with specific learning disabilities.

From a methodological perspective, the research stands out for its structured design, including pre- and post-intervention assessments, a follow-up phase to evaluate retention, and the use of both quantitative and qualitative tools. Nevertheless, the authors acknowledge its limitations, particularly the small number of students with dyscalculia and the absence of stratified statistical analysis for this subgroup. They recommend future investigations with larger, controlled samples to confirm and expand upon these initial results.

## 4. Discussion and Limitations

The integration of social robots into educational interventions for children with SLDs has demonstrated potential to enhance access, motivation, and the overall effectiveness of learning pathways. This trend reflects a growing awareness of the need for customizable, engaging tools that can interact multisensorially with students who present with special educational needs [30] [32].

One of the most salient observations is the capacity of social robots to adapt to different types of SLD and, as shown in Table 2, the variety robots utilized across studies.

In the case of dysgraphia, for example, robots such as NAO, QTrobot, and Cellulo have proven effective in supporting handwriting development [27][23][31]. Particularly promising is the "learning-by-teaching" paradigm employed in the CoWriter project, where the child assumes the role of tutor to the robot. This reversal of traditional student-teacher dynamics has been shown to improve not only the quality of handwriting but also the child's self-efficacy and motivation, which are often hindered by frustration and avoidance behaviors associated with writing tasks [19]. Tangible robots like Cellulo have also shown great promise by providing haptic, real-time feedback during writing activities, supporting fine motor skill development and visuomotor coordination [33].

About dyslexia, robots such as Taban, NAO, Kebbi, and Minibo have emphasized the affective and interactive dimensions of learning [28] [26][22]. By combining verbal and visual feedback with empathetic interaction and playful strategies, these robots have managed to engage children with reduced attention spans. Multimodal robots have shown particular effectiveness by integrating voice, gestures, touch, and movement into a single learning experience. A key point is that children have exhibited clear preferences for robots that can dance, sing, or express emotions, highlighting the importance of designing learning experiences that align with each child's cognitive and emotional profile.

In the case of dyscalculia, we can notice that the field remains less explored. This discrepancy could be attributed to the fact that dyscalculia, unlike other SLDs such as dyslexia or dysgraphia, remains underdiagnosed [37]. Furthermore, many robotic activities related to learning mathematics are part of more general educational contexts [38][39] [40].

However, the initial findings are encouraging. Educational robotics, framed as tangible and problem-solving activities, has helped alleviate math anxiety and facilitated understanding of abstract concepts [36]. Robots such as Ozobot Evo and SAM Labs have been integrated into collaborative and hands-on activities, such as constructing logical paths or solving numerical puzzles.

**Table 2**
Overview of the social robots used in the selected studies.

| Robot | Studies | Interaction Modality | Key Features | Target SLD(s) |
|---|---|---|---|---|
| NAO | [19], [21], [23], [27], [30], [35] | Verbal, gestural, tablet-based, dialogue | Reading support, speech therapy, handwriting correction, early diagnosis | Dysgraphia, Dyslexia |
| Taban | [22], [25] | Tablet + multimodal feedback, VR | Lexicon training, phonological awareness, VR avatar | Dyslexia |
| QTrobot | [31], [34] | Touchscreen, adaptive feedback | Personalized handwriting assessment and training | Dysgraphia |
| Cellulo | [32] | Tangible + haptic feedback | Kinesthetic learning, motor coordination support | Dysgraphia |
| Ozobot Evo, SAM Labs | [36] | Tangible, hands-on robotics + games | Collaborative puzzles, logic tasks, gamified learning | Dyscalculia |
| Kebbi | [26] | Multimodal (gestures, expressive visuals) | Emotional expressivity, visual feedback, engagement | Dyslexia |
| Minibo | [26] | Minimal (verbal only) | Simplified interaction for comparative study | Dyslexia |
| Tablet/App + AI | [23], [33], [34] | Handwriting input + CNN, motion sensors | Writing recognition, pressure/speed/tilt metrics | Dysgraphia |
| iReCheck system | [33] | Modular (FSM + behavior trees) | Posture detection, adaptive decision-making | Dysgraphia |
| VR Avatar (Taban) | [25] | VR-based simulated interaction | Phonological training in immersive environment | Dyslexia |

Across these domains, a number of transversal mechanisms appear to underpin the effectiveness of social robots. First, the emotional engagement generated by robots acts as a strong catalyst for interest and motivation. While this effect tends to fade over time, it can be prolonged through gamification, affective expression, and multimodal interaction [29]. Second, the robots' capacity for real-time personalization, enabled by facial, vocal, and gesture recognition, allows for dynamic adaptation of activities to the child's skill level and pace, thus reducing frustration and sustaining engagement [34]. Finally, robots often create a non-judgmental environment that alleviates performance anxiety and encourages more spontaneous and confident participation [21].

Despite the promising evidence, several limitations and challenges hinder the widespread adoption of social robots in SLD contexts. On the technical side, speech recognition for children remains a critical bottleneck, and many platforms require continuous support from trained operators due to limited autonomy and complex user interfaces. This increases both cost and dependency, thus reducing the scalability of these solutions [25]. From an economic standpoint, the high cost of acquisition and maintenance, especially for robots with haptic capabilities or advanced sensing, poses a significant barrier, particularly in underfunded public educational settings.

Methodologically, most studies still suffer from limited generalizability due to small sample sizes, exploratory or single-case designs, and a lack of replication. The absence of shared protocols and standardized outcome measures further complicates cross-study comparisons. Moreover, the heavy reliance on self-reported data introduces susceptibility to biases such as the novelty effect or participant expectations [32][33].

These limitations highlight the need for a qualitative leap in research design and implementation. Large-scale longitudinal studies, with standardized protocols and objective metrics, such as eye-tracking, neurophysiological markers, or automated behavioral coding, are essential to evaluate the long-term impact of robot-assisted interventions. Simultaneously, advances in robotic autonomy and artificial intelligence, including integration with generative language models, emotional recognition systems, and adaptive learning algorithms, are critical to reducing the burden on human operators and enhancing system scalability.

Equally important is investment in teacher training and technological infrastructure. Professional development programs must prepare educators and therapists to effectively implement and manage robotic systems, while policy initiatives should aim to promote equitable access to such technologies.

## 5. Conclusion

This work provides an overview of the state of the art concerning the use of social robots in the context of SLDs, with particular attention to dyslexia, dysgraphia, and dyscalculia. The studies reviewed highlight the maturity of this research field, with interventions moving from exploratory setups toward structured implementations in real-world educational and clinical environments.

Observed outcomes demonstrate that social robots can effectively support the acquisition of academic skills by promoting engagement, motivation, and emotional resilience in learners with SLDs. These benefits are achieved through personalized interaction, multimodal feedback, and the ability to create emotionally supportive and non-judgmental learning environments. Specific robot platforms, such as NAO, QTrobot, Cellulo, and Taban, have been shown to be particularly suitable when aligned with the cognitive profiles and therapeutic goals of the target population.

Despite these encouraging outcomes, the literature also points to important challenges, including limited generalizability due to small samples, a lack of standardized methodologies, and persistent technical constraints related to autonomy, usability, and cost. These barriers must be addressed through larger, longitudinal studies, interdisciplinary co-design approaches, and institutional investment in teacher training and technological infrastructure.

In future directions, the integration of social robotics into inclusive education holds considerable promise. If paired with advances in AI and adaptive learning systems, and guided by robust ethical and pedagogical frameworks, these technologies may evolve into sustainable, scalable tools capable of transforming support for students with SLDs in both formal and informal learning contexts.

Due to the vulnerability of the target population, future extensions of this overview could consider ethical and social aspects, particularly data privacy, robot-child relationships, and potential technology addiction. Furthermore, this work can be expanded by considering additional datasets and using specific screening and selection protocols (e.g., the PRISMA framework).

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## Declaration on Generative AI

During the preparation of this work, the author(s) used GPT-4 and Grammarly to: Grammar, spelling check, and to rephrase some sentences for clarity and fluency. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication’s content.

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