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Abstract

This working paper examines how artificial intelligence (AI) can support students with special education needs (SEN) to achieve their learning goals, while underlining key risks and limitations. It defines central terms and the rationale for using AI in this context and reviews a selection of research-backed AI tools that aim to empower students with SEN. Based on this review, it highlights risks and limitations to consider and mitigate when procuring, creating and employing AI-enabled tools for students with SEN and beyond. The paper discusses governance and operational mechanisms for ensuring their implementation is ethical, sustainable and secure. It concludes with policy considerations for developing, selecting and integrating AI tools to foster inclusive education, particularly related to ethical design, research and monitoring, data protection and security, and accountability.

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1 Introduction

> "Including children with disabilities in all aspects of life must be a priority. Every child, everywhere, has something to offer." (UNICEF, 2024, p. 6[1])

The effective integration of digital technologies in education has shown potential in supporting students with special education needs (SEN) (Cerna et al., 2021[2]; Gottschalk and Weise, 2023[3]; OECD, 2023[4]). Digital learning environments and intelligent tutoring systems can enhance teaching and learning processes for students with SEN (Good, 2021[5]); assistive technology (e.g. refreshable Braille displays, captioning software, personal digital assistants) can help remove barriers for individuals with SEN to learn and participate fully in society (UNESCO, 2020[6]).

These digital technologies have shown the potential to facilitate the inclusion of students with SEN in mainstream education settings (also referred to as "mainstreaming"), assuming the necessary human and financial resources are available to these schools (see Box 1.1 for definitions) (Good, 2021[5]; UNESCO, 2020[6]). Research also shows that mainstreaming can improve their academic outcomes, social skills and behaviours while increasing the likelihood they enrol in higher education (Mezzanotte, 2022[7]; OECD, 2022[8]). Mainstreaming also enhances social inclusion by fostering friendships and peer interactions, which are fundamental for developing social skills, communication abilities and a sense of belonging (Ibid.). Among students without SEN, inclusive settings improve tolerance, reduce prejudice and have either neutral or positive effects on their academic outcomes (Ibid.). Economically, it enhances vocational opportunities for students with SEN, as evidenced by increased earnings and economic independence in countries like China, Norway, and the Philippines (Mezzanotte, 2022[7]; Myklebust and Ove Båtevik, 2005[9]; Liao and Zhao, 2013[10]; Mori, Reyes and Yamagata, 2009[11]).

With the recent acceleration of AI systems, particularly generative AI technologies, researchers, policy makers, practitioners and other education stakeholders are interested in finding out the ways in which it will affect education quality and inclusion (OECD, 2023[12]; Varsik and Vosberg, 2024[13]; Good, 2021[5]; UNESCO, 2021[14]; Holmes et al., 2022[15]; Cobo, Munoz-Najar and Bertrand, 2024[16]; European Commission, 2023[17]; OECD, 2024[18]). Although many stakeholders recognise the potential for AI to benefit students with SEN, there are substantial research and evidence gaps regarding its benefits and risks (Hopcan et al., 2022[19]; Holmes, 2023[20]). However, as AI technologies continue to improve and their impact becomes more widespread, so does the opportunity to use these technologies in educational settings for supporting students with SEN.

To begin responding to this knowledge gap, this paper explores the potential opportunities in AI for supporting students with SEN, while underlining the risks and limitations. First, it defines key terms and the rationale for using AI technologies to support students with SEN. Second, it reviews existing AI-enabled tools[1] that aim to empower students with SEN (Section 2). Third, it summarises the risks and limitations of procuring, creating and using AI tools for students with SEN and beyond (Section 3). Fourth, it highlights important governance and operational mechanisms that can ensure the effective, ethical, environmental, and secure implementation of AI-enabled tools in education systems (Section 4). Finally, it proposes policy considerations related to developing, selecting and integrating AI-enabled tools for supporting students with SEN (Section 5).

Context, definitions and terminology

Before analysing the available tools, several terms must be defined and contextualised.

Disabilities and special education needs

In the context of education, the literature generally refers to disability and special education needs (SEN). This paper adopts a biopsychosocial definition of disability, which involves factors related to the individual and their environment (UNICEF, 2021[21]). Disability can occur as an impairment in body function/structure (e.g. eye cataract), a limitation in activity (e.g. low vision) or a restriction in participation (e.g. exclusion from school; Ibid.). SEN is a term used in many education systems to characterise the broad array of needs of students and learners who are affected by learning disabilities (i.e. dyslexia, dysgraphia), physical impairments (i.e. hearing and visual impairments), and mental disorders (i.e. autism spectrum disorder (ASD), Attention Deficit/Hyperactivity Disorder (ADHD) (Cerna et al., 2021[2]). They are defined as follows:

1. **Learning disabilities** are neurological disorders (with a genetic component) that affect the ability for individuals to understand or use spoken or written language, do mathematical calculations, coordinate movements, or direct attention (Cerna et al., 2021[2]; Brussino, 2020[22]). These disorders do not impact the intelligence of an individual, but can make it difficult for an individual to fulfill their potential in school without support (UNICEF, 2021[21]). Individuals with learning disabilities may experience symptoms of varying levels of severity depending on co-morbidity (i.e. presence of one or more additional medical or mental health conditions alongside a primary condition). Some of the most common learning disabilities are dyslexia, dysgraphia and dyscalculia.
2. **Physical impairments** can prevent individuals from accessing physical spaces, information and social interactions (Brussino, 2020[22]). These impairments can affect one's hearing, vision, speech and mobility, which may have hereditary components or be the result of a disease or traumatic event that produced long-lasting physical consequences. The most common physical impairments include visual and hearing (sensory), speech and mobility impairments (Cerna et al., 2021[2]).
3. **Mental disorders** are characterised by a significant disturbance in an individual's cognition, emotional regulation or behaviour (World Health Organization, 2022[23]). Poor mental health may be a consequence of a lack of support for students experiencing disabilities/impairments, or a medical condition that acts as a barrier to academic progress and well-being (OECD, 2023[24]). The experiences of students in school can contribute to the onset of certain mental health disorders, often linked to factors such as bullying, social isolation and stress (Brussino, 2020[22]). The majority of mental disorders begins during school years, often by the age of 14 (Ibid.). Some of the most common mental disorders affecting children in school include ASD and ADHD.

Despite educational attainment of students with disabilities improving over the past decades in most OECD countries, there is still a persistent disability gap in education and skills that starts early in life (OECD, 2022[8]). The difficulties that children face related to their disabilities, as well as their socio-economic background, can negatively impact their school attendance and achievement, well-being and employment outcomes (Brussino, 2020[22]; UNICEF, 2021[21]). UNICEF estimates that 50% of the 93 million children living with an impairment or disability are not in school, compared to 13% of peers without disabilities (Mezzanotte, 2022[7]). Students with learning disabilities are twice as likely to leave school before completing their education compared to their peers (Greet, 2017[25]). Young people with mental health conditions are especially vulnerable to social exclusion, discrimination, stigma (which can hinder their willingness to seek support), challenges in education, engagement in risky behaviours, physical health issues and human rights violations (World Health Organization, 2024[26]). Similarly, students with physical impairments, if unsupported, may suffer from low levels of academic, social, psychological and physical well-being (Ibid.).

Among adults, almost 50% with permanent disability have low literacy skills and 55% low numeracy skills compared to just over 20% and 25% of those without a disability, respectively (OECD, 2022[8]). Moreover, individuals with a disability in OECD countries have lower higher education completion rates compared to their peers, according to data from the Washington Group on Disability Statistics (Mezzanotte, 2022[7]).

An employment gap also exists. According to 2019 data from 32 OECD countries, the employment rate of people with a disability was 27 percentage points lower than for people without a disability (Ibid). Women with disabilities are at more of a disadvantage socio-economically than their male counterparts. In the European Union, 29.2% of women (compared to 27.4% of men) with disabilities are at risk of poverty and social exclusion (European Commission, 2022[27]). About 49% of women with disabilities are employed compared to 53.9% of men with disabilities (Ibid).

Among individuals leaving education in the United Kingdom between 2020 and 2021, individuals with learning disabilities (self-reported) had a sustained employment rate of 53% compared to 74% of those with no learning disabilities (Nelson and Anderson, 2024[28]). A study conducted by the Science Division of the British Government in 2008 found that dyslexia and dyscalculia can reduce lifetime earnings by GBP 81,000 and GBP 114,000, respectively (UNESCO MGIEP, 2017[29]). Individuals with physical impairments often face compounded disadvantages with lower levels of educational attainment, including lower household income and reduced likelihood of securing employment (Mezzanotte, 2022[7]). These challenges are particularly pronounced in households with children with impairments, especially in contexts where inclusive education policies are lacking, leaving parents to undertake full-time caregiving responsibilities (Ibid.). People who experience mental disorders can also have a difficult time maintaining employment, being effective at work and staying physically fit (OECD, 2023[24]). These disorders can affect individuals' energy levels, concentration, dependability and optimism, making it difficult to perform at school and work (Ibid.).

Box 1.1. Definitions of terms related to equity and inclusion in education

Equitable education systems are those that ensure the achievement of educational potential regardless of personal and social circumstances, including dimensions such as gender, ethnic origin, Indigenous background, immigrant status, sexual orientation and gender identity, and special education needs. These factors intersect with each other and two overarching factors, namely socio-economic status and geographic location (Cerna et al., 2021[2]; OECD, 2017[30]; OECD, forthcoming[31]).

Inclusive education is "an on-going process aimed at offering quality education for all while respecting diversity and the different needs and abilities, characteristics and learning expectations of the students and communities, eliminating all forms of discrimination" (UNESCO, 2009[32]). The goal of inclusive education is to respond to all students' needs, going beyond school attendance and achievement, while improving all students' well-being and participation (Cerna et al., 2021[2]).

Mainstream education settings include "learners with special education needs into general educational settings or regular schools", while addressing the needs of all students and ensuring full participation (UNESCO, n.d.[33]).

Note: The definitions were adopted by the Education for Inclusive Societies (and the previous Strength through Diversity) project. Other organisations, projects, countries and researchers may use different definitions.
Source: OECD (2023[24]), Equity and Inclusion in Education: Finding Strength through Diversity, https://doi.org/10.1787/e9072e21-en.

Artificial intelligence

With the increasing use and prevalence of systems such as ChatGPT, Google's Gemini search engine, and Microsoft Copilot, AI has become ubiquitous in today's technological landscape. AI-enabled tools have been used in educational contexts for a variety of reasons, such as adapting learning (e.g. AI tutors), enriching content (e.g. AI-enhanced simulations for exploring scientific phenomena), providing universal access to information (e.g. class timings, submission deadlines), supporting research practices (e.g. brainstorm possible causes using generative AI tools) and assisting students with SEN (Varsik and Vosberg, 2024[13]).

AI tools can help students with SEN access educational content, as well as receive support for mental health (Varsik and Vosberg, 2024[34]). However, using AI to diagnose and/or respond to mental health needs is a delicate, complex matter that should draw on the expertise of relevant professionals across development and implementation phases. For instance, AI-enabled robots can assist teachers to respond to the psychological and behavioural needs of students, in addition to creating safe, personalised opportunities for students with ASD to practice social skills (Ibid.). Another example is adaptive learning platforms that harness AI techniques to tailor activities in real-time to meet specific needs of each student in a diverse classroom (Ibid.). AI-enabled simulations (e.g. augmented reality) aim to offer students with SEN supportive environments to develop social and cognitive skills (Ibid.). AI tools can thus help foster inclusive and equitable learning environments, for example by helping students with SEN to work with their peers on the same activity (e.g. in a textbook) thanks to adaptive formats and assistive tools (Ibid.).

However, AI systems are not a monolith – understanding how they can be used productively requires an understanding of how they work and what they can offer to inclusive education.

A few definitions can provide a basis for this understanding:

- An **artificial intelligence (AI) system** is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment (OECD, n.d.[35]). AI systems are driven by the data sets they are fed for training them to generate the desired outputs.
- **AI techniques** are methods and approaches used to solve specific tasks or problems, as well as underlying mathematical and computational processes that enable AI systems to learn, reason, and make decisions. Examples include machine learning algorithms, deep learning, and neural networks (UNESCO, 2022[36]).
- **AI technologies** are hardware and software instruments, frameworks and platforms that enable the implementation of AI techniques to create AI applications. Examples include autonomous agents (avatars, chatbots, robots), image and speech recognition and natural language processing (UNESCO, 2022[36]).
- **Generative AI** is a type of AI technology designed not only to identify patterns in data but also generate new content, including text, images, music and more (OECD, n.d.[37]).
- **Large language models (LLMs)**, a common type of Generative AI, are machine learning models that identify statistical relationships within large corpora of text data, capturing patterns, structures and usage nuances. They are generative in nature, taking text as input (i.e. a prompt) and generating plausible and contextually relevant text as output (TechTarget, n.d.[38]).

With these terms now defined, it is possible to explore the opportunities available for supporting students with SEN through the review of AI-enabled tools (or "AI tools") that employ AI techniques and/or integrate AI technologies for use in educational settings.

2 Current landscape of AI tools for students with SEN

There are some promising examples of AI tools that might respond to the specific needs of students who fit under the broad umbrella of SEN, including those who experience learning disabilities, sensory, speech and/or physical impairments, ASD and ADHD - though there is no one-size-fits-all approach to addressing these needs. The examples of AI tools described in this paper were selected if they[2]:

a) take an evidence-based approach, either having already conducted research studies or clear plans to do so;

b) aim to support the learning and participation of students with SEN, without framing these students as needing to be “fixed”; and

c) have inclusive elements to highlight (e.g. using inclusive datasets, actively considering perspectives of various actors in the development and improvement of the tool).

While this section is organised by SEN for practical reasons, some AI-enabled tools target multiple needs. These are mentioned in the description of those tools. It is also important to note that the AI tools described in this paper serve to showcase important aspects of AI technologies and research on the use of AI in the context of SEN. Their inclusion in this paper should not be misconstrued as an OECD endorsement for their use. Given various risks and limitations apply across these different tools, they are discussed in a dedicated section (see Risks and limitations).

Although generally focused on AI tools aimed to support students with SEN in compulsory education at the primary and secondary levels, there are also several examples from other levels of education (e.g. early childhood and care and higher education).

AI tools for learning disabilities

Dyslexia

Individuals with dyslexia experience difficulties in learning academic skills related to reading and writing, such as word reading accuracy, reading fluency and reading comprehension (World Health Organization, 2019[39]). It is estimated that around 15% to 20% of the world population have some of the symptoms of dyslexia (International Dyslexia Association, 2020[40]). Dyslexia can negatively impact individuals' educational and professional outcomes, as well as their emotional well-being, self-esteem, and social relationships and behaviours (Livingston, Siegel and Ribary, 2018[41]). The social and emotional issues can remain and even escalate into adulthood, which highlights the importance of early detection and targeted support for students with dyslexia (Ibid).

Currently, a range of digital technologies are available to help students with dyslexia, such as reading trackers, audiobooks, augmented reality, educational games (e.g. GraphoGame), web-browser plugins and learning platforms. These tools provide options for reading support (e.g. changing font, text size, background colour), detecting and diagnosing needs early on and supporting the development of skills (Good, 2021[5]; Gottschalk and Weise, 2023[3]; Brussino, 2020[22]; Forsström, Njå and Munthe, Forthcoming[42]).

AI may provide additional opportunities for support by detecting dyslexic tendencies and adapting learning content and how it is delivered to individual students (Box 2.1). For example, Change Dyslexia, with support from the European Commission, is developing "Dytective", a set of two digital tools that screen and train students with dyslexia in reading through game-based exercises (Change Dyslexia, n.d.[43]).

Another example is the AI-enabled platform, BESPECIAL, that predicts the support needs of students based on various sources of data. It provides content and tools tailored to students' specific needs (e.g. concept maps and learning strategies) (IRCAI, 2021[44]). It also recommends best strategies to teachers and university institutions, such as the presence of tutors (Zingoni et al., 2021[45]).

Similarly to BESPECIAL's outputs for education providers, the Learning Engineering Virtual Institute (LEVI)'s AI Lab is developing an open-source chatbot for teachers and parents to support young students who struggle to learn to read, including students with dyslexia (Lee, 2024[46]). The 'early literacy' chatbot is trained on a curated dataset of expert-reviewed resources, which prepares it to give evidence-based recommendations on learning plans for students. The LEVI Lab is also integrating feedback from parents, educators and researchers to improve the next implementation of the tool, ensuring it meets real needs.

Targeting skill development, KOBI is an AI-enabled reading application that provides personalised, science-backed learning strategies to students with dyslexia (KOBI, n.d.[47]). As students read aloud, the advanced speech recognition technology allows the app to give real-time feedback and adapt to the student's learning pace (Ibid.). Moreover, the speech recognition technology operates on the user's device to ensure voice data remains private and secure (Ibid.) In 2024, KOBI was introduced into general classrooms across Slovenia, with support from the Ministry of Education (EdTech Slovenia, 2024[48]).

The potential impact of AI for students with dyslexia is still unclear, but these tools show promise because they leverage one of AI's greatest assets – the ability to analyse large data sets – to support adaptive learning. This is particularly useful for students with dyslexia, given the diversity of its manifestation.

Box 2.1. Research-backed tools that harness AI to support students with dyslexia

Dytective by Change Dyslexia

Partly funded by the European Commission, the Change Dyslexia project brings together artificial intelligence, computer games, linguistic studies and data analysis to diagnose and train students with dyslexia on a large scale. It aims to detect dyslexia early (dependent on the confirmation of the diagnosis by a professional), overcome academic difficulties arising from dyslexia and provide scholarships to ensure students can access the training they need.

The DytectiveU Test combines linguistic items with machine learning to diagnose people from 7 to 70 years old with an 80% reliability (Rello et al., 2016[49]). The DytectiveU application provides students with dyslexia over 40,000 game-based exercises of which the type and difficulty are adapted according to students' strengths and weaknesses, and can be used on mobile phones, tablets and computers (Aviles Agama and Milanés Gómez, 2021[50]). Linguists, psychologists and computer scientists developed the large bank of exercises (see example item in Figure 2.1) by harnessing 1) linguistic patterns extracted from errors made by people with dyslexia using data mining techniques; and 2) linguistic resources generated by natural language techniques (Rello et al., 2017[51]).

A between-group experiment involving over 60 Spanish-speaking dyslexic students was conducted over 6 months. Both groups received professional language training, while the experimental group also used DytectiveU games for eight weeks. Using a pre- and post-test design, the experiment showed that children in the experimental group demonstrated significantly higher rates of improvement in three tasks related to literacy acquisition (European Commission, 2020[52]). As of 2020, DytectiveU has been used in over 130 countries (Ibid.).

Figure 2.1. Example of an exercise targeting phonological and lexical awareness

Source: Rello, L., Macías, A., & Bigham, J. (2017[53]). DytectiveU: A game to train the difficulties and the strengths of children with dyslexia. In ASSETS '17: Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility, Baltimore, USA.

BESPECIAL by VRAllexia

With the aim of filling the gap of AI tools that support dyslexic students during the academic year, BESPECIAL is an open-source software platform that uses AI to support dyslexic university students with customised digital supporting tools and personal learning strategies (IRCAI, 2021[44]). The platform was developed by VRAllexia, an Erasmus+ project comprised of seven universities, two vocational education and training (VET) providers and one private company from Belgium, France, Greece, Italy, Portugal, and Spain.

Considering the heterogenous experience of dyslexia among students, the project built an AI assessment module that inputs clinical reports of dyslexia, responses to a self-report questionnaire about difficulties faced during studies and potential tools (the instrument was based on interviews of 20 dyslexic university students), as well as results from a battery of psychometric tests that are administered using virtual reality to ease accessibility and increase engagement (Zingoni et al., 2021[45]). The AI module uses a machine learning algorithm that improves its predictions based on these data and human-driven knowledge about dyslexia. As students use the supporting tools and strategies, their behaviours and performance are fed back into the algorithm to update the predictions to ensure tailored support and customised material (Ibid). Moreover, the platform provides best practices to teachers and university institutions for supporting students with dyslexia.

The project aims to monitor the effectiveness of this AI tool by testing it quarterly and measuring the reduction of dropout rate, the increase of dyslexic students enrolled in university and the reduction of the European Credit Transfer and Accumulation System gap obtained by dyslexic students. Although final results had not been reported at the time of this paper's publication, preliminary results from around 700 dyslexic students informed improvements to the implementation of BESPECIAL (Zingoni et al., 2021[45]).

Early literacy chatbot by LEVI's AI Lab

The early literacy chatbot aims to help teachers, support personnel and parents feel safe to ask questions about reading challenges faced by their student(s) and help them save time while not compromising the depth of research. The chatbot provides evidence-based support plans and resources.

Importantly, users can be confident in the quality of its recommendations because the ChatGPT-powered tool was primarily trained on the United States Department of Education's Doing What Works dataset. The process of training the model on a smaller, targeted dataset is called fine-tuning, which is important because it can help adapt the vast ChatGPT model to do specific tasks in targeted domains (Ray, 2023[54]). This results in more accurate and relevant responses. The dataset comes from the What Works Clearinghouse (WWC), which is a group of hundreds of trained and certified reviewers that read and rate studies (over 10 000 studies have already been reviewed), assess the rigor of their methods and summarise those studies that meet their rigorous standards. The WWC then creates intervention reports, reviews of individual studies and practice guides (Institute of Education Sciences, n.d.[55]).

With funding from the Walton Family Foundation, the Learning Engineering Virtual Institute (LEVI)'s AI Lab continues to develop this open-source tool in collaboration with experts, researchers, teachers and students (Lee, 2024[46]). Preliminary feedback from users, including parents, educators, and researchers is positive.

Dysgraphia

Individuals with dysgraphia experience difficulties in learning academic skills related to writing, such as spelling accuracy, grammar and punctuation accuracy and the organisation and coherence of ideas in writing (World Health Organization, 2019[39]). Although some research studies investigate the prevalence of dysgraphia, it is unclear which proportion of the population experiences dysgraphia due to variability in diagnostic criteria, methodologies and awareness (Biotteau et al., 2019[56]). Dysgraphia can create barriers for the acquisition of other skills and performance of core activities (e.g. note-taking, self-expression), as well as negatively impact students' self-esteem and in turn, their academic success (Danna, Puyjarinet and Jolly, 2023[57]; Asselborn, Chapatte and Dillenbourg, 2020[58]).

Various digital technologies exist to support individuals with dysgraphia, such as low-tech assistive technologies (e.g. adapted pencils, papers and graphic organisers) and word processing software (Brussino, 2020[22]). Digital tablets have provided new opportunities for better understanding dysgraphia because they can consider the process of students' handwriting, in addition to the final product. This additional information can help with detecting dysgraphia, as well as supporting students who experience various aspects of the disorder (Asselborn, Chapatte and Dillenbourg, 2020[58]; Zolna et al., 2019[59]).

Given the variability of symptoms and the need for expert assessment (e.g. administered by therapists) for diagnosing dysgraphia, AI techniques like machine learning are being used to automate the diagnostic assessment and remediation of dysgraphia (Kunhoth et al., 2024[60]; Good, 2021[5]). One scientifically proven example is Dynamilis, which is a software that helps educational providers identify handwriting issues and students (aged 5-12) improve their handwriting (see Box 2.2).

Despite recognition that a lack of support of dysgraphia is a barrier to equitable learning outcomes, there is a paucity of scientifically validated AI-based tools that support dysgraphia. Existing tools show promise, but they often lack relevant evidence, limiting their credibility and scalability (and thus their inclusion in this review). Robust research is still required to explore how AI can be integrated into inclusive educational practices. Such efforts should prioritise user-centred design and consider the diversity of needs among individuals with dysgraphia to ensure these tools are not only accessible but also equitable.

Box 2.2. Research-backed tool that harnesses AI to support students with dysgraphia

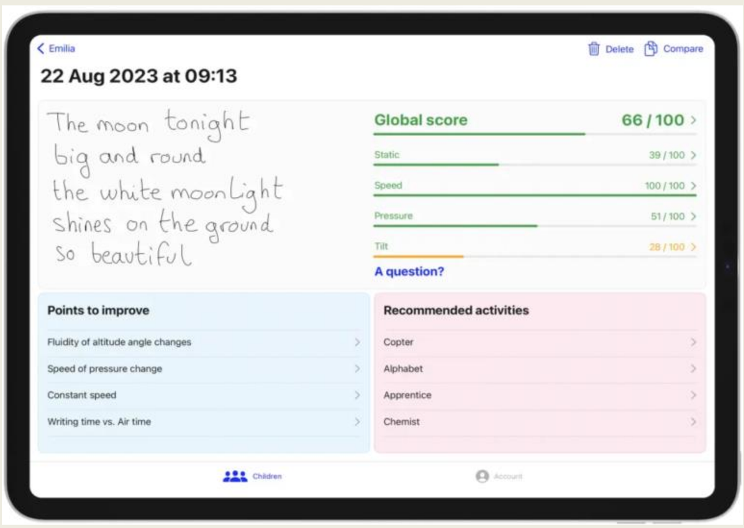
Dynamilis by School Rebound

Originating in EPFL's CHILI Laboratory (Computer-Human Interaction in Learning and Instruction) in 2018, a Swiss edtech start-up called School Rebound launched Dynamilis (formerly named Dynamico) in 2022. This trilingual software (English, Italian, German) asks students to use a stylus pen and a tablet to demonstrate and improve their writing skills by working through interactive activities (School Rebound, n.d.[61]; Crépin, 2023[62]). It was developed with feedback from schools, students, parents and therapists, and the scientific framework of the tool is overseen by a scientific and ethical board composed of experts in dysgraphia, dyslexia, data science and education (Ueberschlag, 2021[63]).

In the first part of the tool (the assessment), machine learning techniques analyse students' writing processes and final responses to assess specific areas of their handwriting: precision (e.g. letter shape), speed, pressure, and dexterity (via tilt). Based on their overall score and sub-scores for each area, the AI-enabled software provides personalised feedback and recommendations for which learning activities to work on next (Asselborn, Chapatte and Dillenbourg, 2020[58]). See Figure 2.2 for an example of a digital dashboard that summarises the score, aspects to improve and recommended next tasks for an individual student. In a study conducted in 2018 in which they compared the standard test to their new digital approach, the research team found that the machine learning algorithm could detect dysgraphia with a high degree of accuracy at approximately 96% (Asselborn et al., 2018[64]). With data on over 50 features of handwriting, including dynamic features, they were able to pinpoint which ones distinguish handwriting of children with and without dysgraphia (Ibid.).

The dataset upon which the AI model is based continues to grow, from a few hundred data points (collected from children with and without dysgraphia who copied text onto a tablet with a sheet of paper overlaid on the surface) to over 15,000 as of 2023 (Crépin, 2023[62]). A larger dataset can help improve accuracy and relevance of recommendations provided by the AI system.

Figure 2.2. Example digital dashboard summarising individual student's results and personalised learning paths



Source: School Rebound (n.d.[65]), Help your kids improve their handwriting - Dynamilis, https://dynamilis.com/ (accessed on 6 January 2025).

For the second part of the tool (learning), twelve games were co-created with teachers and therapists, which target specific aspects of handwriting. Figure 2.3 shows the example game, Pursuit, which asks students to follow a path of pre-scriptural shapes commonly found in letter formations to build accuracy and control (School Rebound, n.d.[61]). Students lose points and balloons when the monkey in the basket goes outside the line. As students complete levels, the complexity of the shapes increase along a logical learning progression. Other activities help students work on other skills, such as lifting the pen when writing in cursive, precision, and spatial orientation. Thanks to the granular information on students' strengths and weaknesses across various areas from the assessment, the recommended learning activities target their specific needs (Asselborn, Chapatte and Dillenbourg, 2020[58]).

Figure 2.3. Example level in the learning game, "Pursuit", targeting handwriting accuracy and control

Source: School Rebound (n.d.[65]), Help your kids improve their handwriting - Dynamilis, https://dynamilis.com/ (accessed on 6 January 2025).

Dyscalculia

Individuals with dyscalculia experience difficulties in learning academic skills related to mathematics or arithmetic, such as number sense, memorisation of number facts, and accurate mathematical reasoning (World Health Organization, 2019[39]). Dyscalculia is estimated to impact up to 7% of the population and frequently coexists with dyslexia (Dyscalculia.org, n.d.[66]; Mader, 2023[67]; Colorado Department of Education, 2020[68]). Beyond the academic challenges, dyscalculia can hinder daily activities that require numerical understanding, such as managing money, measuring quantities and monitoring time (Understood.org, 2017[69]). It can also play a role in social and economic outcomes. Although not limited to dyscalculia, low numeracy outcomes can negatively impact individuals' employment opportunities, earnings, and health, as well as economic growth at the societal level (Butterworth, Varma and Laurillard, 2011[70]).

Compared to dyslexia, there are fewer research-based digital tools designed to support students with dyscalculia. However, there are several examples being developed by research teams, such as a learning platform that helps students represent numbers and perform simple calculations with their fingers (Good, 2021[5]), serious games (Hocine, Moussa and Ali, 2023[71]; Dhingra et al., 2022[72]; Butterworth, Varma and Laurillard, 2011[70]) and assistive technology tools, such as equation-solving tools (Understood, 2023[73]).

There are even fewer examples of AI-enabled tools that target dyscalculia and are backed by research. Similar to the AI tools for dyslexia reviewed earlier, the most promising AI tools for dyscalculia also personalise learning content to meet students' individual needs. Calcularis 2.0, further described in Box 2.3, uses AI to analyse students' responses and behaviours, identify error patterns and assign learning games according to students' unique needs (Constructor Tech, 2025[74]). Although this tool is backed by research, it is difficult to know if the tool can be scaled up successfully to students from different backgrounds and contexts because there is a lack of evidence.

Box 2.3. Research-backed tool that harnesses AI to support students with dyscalculia

Calcularis 2.0 by Constructor Tech

Calcularis 2.0 is an adaptive computer-based learning programme for children with dyscalculia. Developed by Constructor Tech and backed by research from leading universities in Switzerland and Germany, it aims to help students automatise different number representations, form and access a mental number line, and use arithmetic operations and fact knowledge. Students play through instructional games (see an example in Figure 2.4) that integrate visual, auditory and kinesthetic elements in their instruction to enhance mathematical comprehension. The games target two areas: 1) number representations and number processing; and 2) cognitive operations and procedures with numbers.

Figure 2.4. Example task from Calcularis 2.0 on magnitude comparison non-structured stimuli

Source: Kohn, J. et al. (2020[75]), "Efficacy of a Computer-Based Learning Program in Children with Developmental Dyscalculia. What Influences Individual Responsiveness?", Frontiers in Psychology, Vol. 11, https://doi.org/10.3389/fpsyg.2020.01115.

Calcularis 2.0 uses an AI-enabled adaptive system that assigns the next task based on the student's learner model that updates in real-time. The mathematics programme comprises over 250 hierarchical skills represented as a dynamic Bayesian network. Each skill is mapped to a game. As students play through different games, the system infers from their work whether they already know the skill, as well as their knowledge of other skills (made possible with the representation of skills in the hierarchical, connected network). It therefore provides personalised skill scaffolding based on individual learning needs. For example, a student struggling with multiplication might be given additional tasks that reinforce prerequisite skills, such as repeated addition. It can also analyse student behaviours and identify error patterns to provide targeted exercises to address them.

An international research team carried out a randomised controlled trial in which 67 students with dyscalculia from second to fifth grade were randomly assigned to a control group (regular instruction) or an experimental group (used Calcularis 2.0) for up to 13 weeks. Results indicate the experimental group exhibited greater improvement in arithmetic operations and number line estimation compared to the control group. Mental number line representation helps individuals conceptualise numbers as being ordered and spaced along a continuum, and this understanding is fundamental for basic arithmetic as well as for more advanced mathematical reasoning. These improvements were stable, shown by a three-month follow-up test. Evaluative studies on the previous version of the programme, Calcularis 1.0 that featured fewer training forms and no reward system, showed similar, albeit weaker, results.

Calcularis 2.0 also provides teachers with automated feedback on their performance via learning reports, class overviews and individual learner error analysis. This frees up time for teachers to give personalised support.

Source: Kohn, J. et al. (2020[76]), "Efficacy of a Computer-Based Learning Program in Children With Developmental Dyscalculia. What Influences Individual Responsiveness?", Frontiers in Psychology, Vol. 11, https://doi.org/10.3389/fpsyg.2020.01115.

AI tools for physical impairments

Sensory impairments (visual and hearing)

Sensory impairments affect individuals' ability to access information that is delivered in specific ways, such as visual formats for those with visual impairments and auditory formats (voice and sounds) for those with hearing impairments (Brussino, 2020[22]). Visual impairments, eye conditions that affect the visual system and one or more of its vision functions, make it difficult to perform everyday activities related to vision, such as reading and mobility (World Health Organization, 2019[77]). Individuals with hearing impairments are not able to hear as well as someone with normal hearing (i.e. 25 dB or better in both ears), the impairment may affect one or both ears, and it may also be difficult to produce information through sounds (World Health Organization, 2021[78]). For visual and hearing impairments, the severity of symptoms can vary.

According to the World Health Organization (WHO), over 430 million people, including 34 million children, have hearing loss of moderate or higher severity in their better hearing ear (World Health Organization, 2021[78]). The WHO also estimates that over 2.2 billion individuals globally experience vision impairment or blindness. Among these, at least one billion cases involve visual impairments that were either preventable or remain unaddressed (World Health Organization, 2019[77]). The vast majority of people affected by visual and/or hearing impairments live in low- and middle-income countries (Ibid.).

Hearing loss can negatively impact individuals' communication, development of language and speech, cognitive skills, educational outcomes, mental health and interpersonal relationships (World Health Organization, 2021[78]). The WHO estimates that unaddressed hearing loss costs globally over USD 980 billion annually, which involves health care, education, productivity losses and societal costs (Ibid.). Vision is important across the life cycle for educational attainment, the development of social skills and participation in social activities, participation in the labour force, management of health conditions, as well as maintaining mental health and well-being (World Health Organization, 2019[77]). Unaddressed vision impairment translates to similar costs to unaddressed hearing loss; the WHO estimates that annual global productivity losses are around USD 410.7 billion (World Health Organization, 2023[79]).

There are some well-known assistive technologies (AT) that can help students who experience blindness, visual impairments, deafness and hearing impairments participate in mainstream educational settings and practices. Some examples of AT include speech-to-text, text-to-speech, subtitles, voice recognition, screen readers, Braille switchers, and wearable technology, which make it possible for students to access learning materials and participate in educational activities (OECD, 2021[80]; Gottschalk and Weise, 2023[3]). These applications can help students with sensory impairments gain independence, improve social interactions and increase motivation and self-esteem (Brussino, 2020[22]). Their use at school also fosters a school environment that celebrates diversity and inclusion.

The most valuable contribution of AI to assistive technologies is its ability to personalise support based on individual needs. Natural language processing, as well as machine and deep learning techniques have been developed and used in technologies designed to assist individuals with blindness, deafness and dual sensory loss (Zdravkova et al., 2022[81]). For example, machine learning is increasingly applied to computer vision tools, such as video description technologies, to improve the accuracy of object detection, classification and extraction of relevant information from images and videos (Ibid.). The aRTIFICIAL iNTELLIGENCE for the Deaf (aiD) project uses machine and deep learning techniques to enhance communication and access to educational material for students who have hearing impairments (see Box 2.4).

For people with visual impairments, Read Speaker is a text-to-speech system that offers AI voices that "read" text to the user (ReadSpeaker, n.d.[82]). It can also highlight on-screen each word as it is read aloud and allow users to change the size of the text for easier viewing (Ibid.). Its machine learning model based on authorised voice recordings (and not those of users) produces over 200 life-like synthetic voices to ease comprehension and supports over 50 languages (Ibid.).

AI can also be used to adapt content. UNICEF's Accessible Digital Textbooks for All initiative aims to make textbooks accessible for students with disabilities by following Universal Design for Learning (UDL) guidelines and offering flexible delivery formats (see Box 2.4).

The mDREET (mobile Detection, Research, Education, Equipment, Training) programme provides a mobile hearing loss detection test for children who are entering schooling (as well as for other life stages) and an AI-enabled application that turns a smartphone into a personalised hearing aid (Touzet, 2023[83]; Venkataraman, n.d.[84]). In collaboration with universities and health organisations in Canada, the United States and the United Kingdom, Solar Ear is using AI to interpret the results of the hearing test administered via a cell phone, and then personalising the hearing aid based on the results (Ibid.). The AI will amplify the missing sounds identified in the individual hearing tests, allowing children to use their phone with earphones to listen to their teacher (MIT, 2022[85]).

Overall, these examples demonstrate that the focus is less on discovering entirely new ways to integrate AI into tools for sensory impairments – an approach more aligned with addressing learning disabilities – and more on enhancing, refining and increasing access to the effective tools that already exist.

Box 2.4. Research-backed tools that harness AI to support students with sensory impairments

aRTIFICIAL iNTELLIGENCE for the Deaf by international collaboration

Funded by the EU's Horizon 2020 programme, researchers from Cyprus University of Technology and Georgia Tech, educational agencies and edtech companies developed a prototype of an interactive digital tutor that uses deep learning models to allow students with hearing impairments to engage with educational material (e.g. class lectures) and communicate with others (Markantonatos et al., 2023[86]). The tutor provides two services: 1) transcription of sign language videos to text, and 2) generation of sign language videos from text prompts. The digital tutor environment follows UDL guidelines to ensure it is accessible, inclusive and equitable for every learner (CAST, 2024[87]). For the transcription service, users can record videos as input to the deep learning algorithm that then produces the corresponding transcription (Ibid.). The transcription achieves a high level of accuracy and uses 70% less computer memory (RAM) to operate efficiently compared to other existing tools (European Commission, 2023[88]; Markantonatos et al., 2023[86]). This can improve the tool's performance, scalability, cost-effectiveness, and usability. For the generation service, users can write text prompts that are sent to the developed deep learning algorithm, which then produces a video of an avatar signing the word or sentence. Pilot study results found that the video generation model excelled in coherency between the text prompt and the corresponding generated sign language video (Markantonatos et al., 2023[86]).

Given each national sign language has its own grammar, syntax and vocabulary, achieving an end-to-end text-to-sign language video translation system requires high-quality machine learning techniques, which, in turn, requires quality training datasets (Markantonatos et al., 2023[86]). The project thus developed the Greek Elementary School dataset, or 'Elementary23' (Voskou et al., 2023[89]). Unlike other datasets that are built by annotating preexisting sign language videos and target a single topic, this dataset consists of over 28,000 high-quality videos of Greek sign language and its corresponding spoken Greek translation in text of authentic elementary school content that covers a wide range of subjects (Ibid.). Expert staff then rigorously selected the final content to ensure its practical value to the deaf community and students. Their pilot results show the dataset has high technical quality and diverse vocabulary (Ibid.). The development of such a dataset can serve as good practice example for developing AI-enabled sign language translation systems for other national sign languages.

Accessible Digital Textbooks for All by UNICEF

The Accessible Digital Textbooks (ADT) for All initiative began in 2016 and is led by UNICEF with Ministries of Education and global partners working on disability inclusion. It draws on expertise from curriculum developers, publishers, teachers, organisations of persons with disabilities, technology developers, national representatives and most importantly, students with disabilities (UNICEF, n.d.[90]). Following UDL guidelines, ADTs aim to help all students, including those who experience blindness, deafness and cognitive disabilities, access educational information in various formats to achieve their learning goals. AI-enabled translation, flexible functionalities and the option to use the textbooks offline facilitate widespread implementation of ADTs by students with and without disabilities.

Manually developed ADTs are created using open-source software like Epub and have been implemented flexibly on country-specific platforms across Latin America, Europe, and Eastern and Southern Africa. Reports from pilots in Jamaica and Paraguay show that the ADTs helped support teachers in their lessons for students with and without disabilities (UNICEF, 2023[91]; UNICEF, 2022[92]). The textbooks have increased motivation, classroom participation, as well as peer support to use the ADTs among children with and without disabilities (UNICEF, 2022[92]). A three-year (2019-2022) implementation in Kenya, Rwanda and Uganda resulted in more interesting outcomes, such as seven key strategies for building an effective ADT ecosystem (de Barbeyrac and Maphalala, 2022[93]).

The initiative is now harnessing AI; students never interact directly with AI for safety and ethical considerations. Using generative AI, written content from PDFs is not only converted into a digital format, but also transformed to create more accessible and engaging content. The underlying code for this AI pipeline will be released and maintained as open-source code in a decentralised manner.

The UDL guidelines allow for students to select and tailor their learning according to their preferences. Rather than directing students to a specific functionality based on their "needs", the ADT offers an array of AI-enabled functionalities from which they can choose. These functionalities include text-to-speech, audio description of images, enlarged text options, subtitles for videos, simplified texts, sectioning the content, and “explain like I am five years old” option.

The transformed content is reviewed by curriculum developers and persons with disabilities before it is released for user testing. UNICEF and the regional offices collect and integrate evidence from students with and without disabilities at all phases of development (de Barbeyrac, 2023[94]). This means collecting feedback from the design and prototyping phase to teacher training, piloting and scaling up phases of the initiative in each country.

Student performance data from the ADTs are stored locally to avoid using cloud-based storage. Teachers can plug these data into dashboards within compatible educational learning management systems, such as Schoology.

In 2025, UNICEF and their partners will conduct further pilot studies, such as an ongoing longitudinal study, to evaluate the impact of the AI-enabled ADT programme on 1) student learning outcomes; 2) inclusion for children with disabilities; and 3) teacher capacity to support their students. They are also implementing a cost-effectiveness study in Uruguay to evaluate the production costs of a manually-built ADT compared to an AI-enabled ADT.

Speech impairments

Speech impairments are disorders related to the articulation of speech sounds, fluency and/or voice (American Speech-Language-Hearing Association, 1993[95]). An articulation impairment is the atypical production of speech sounds, such as through substitutions and additions that interfere with the clarity of the output. A fluency impairment is an interruption in the flow of speaking due to elements like atypical rate, rhythm and repetitions of sounds, words, etc. A voice impairment is the abnormal production and/or absence of vocal quality, pitch, duration, etc. Individuals can also have language impairments related to understanding language and expressing language (American Speech-Language-Hearing Association, n.d.[96]).

Estimating the global prevalence of speech and language impairments presents challenges due to inconsistencies in identification methods, diagnostic criteria and reporting standards (Langbecker et al., 2020[97]). Despite these limitations, national estimates offer valuable insights into the extent to which student populations experience these impairments. In England (United Kingdom), the most common type of need among students with SEN is speech, language and communication needs (25.6% of students with SEN) (UK Department for Education, 2024[98]). Similarly in Hungary, 5% of students with SEN in 2021-2022 were affected by speech disorders (Hungarian Central Statistical Office, n.d.[99]). In France, 18% of students with SEN attending mainstream schools have speech or language impairments (Ministère de l’Education nationale and D. Ministère de l’enseignement supérieur, 2023[100]). In the United States, under the Individuals with Disabilities Education Act (IDEA), 19% of students receiving special education services were identified with a speech or language impairment (National Center for Education Statistics, 2024[101]). The impact of speech and language impairments extends beyond communication. Research highlights that children with these impairments face an elevated risk of mental health challenges, reduced social well-being and lower academic achievement relative to their peers (Langbecker et al., 2020[97]). These findings underscore the importance of early identification and targeted interventions to support these students effectively.

A range of assistive and digital learning technologies are available for supporting students with speech and language impairments. For example, speech recognition and generation tools (i.e. speech-to-text and text-to-speech), delayed auditory feedback tools (e.g. DAF Professional mobile application[3]), dynamic communication boards (e.g. SoundingBoard by AbleNet[4]), and learning platforms with adaptive activities, assessment tools and reporting features (e.g. Smarty Ears[5]).

Artificial intelligence goes a step further by offering new tools for diagnosing speech and language impairments, delivering individualised learning interventions, and supporting spontaneous communication with others (see Box 2.5 for detailed examples). The National AI Institute for Exceptional Education is developing new AI tools to identify speech impairments in early childhood classrooms, and to help Speech Language Pathologists (SLPs) and teachers provide individualised interventions (University of Buffalo, 2023[102]).

An example of how AI can help people with moderate to severe speech disabilities communicate with others is the Voiceitt app, which analyses the unique speech patterns of each user and speaks it back in a computerised voice to facilitate understanding and communication (Voiceitt, n.d.[103]).

These examples demonstrate that AI holds potential in supporting the early identification of speech impairments, the development of personalised interventions and the enhancement of assistive technologies. They showcase good practices related to interdisciplinary teams, appropriate databases, and research goals. However, more evidence is needed to understand the impact of these tools on various outcomes for students with speech impairments across time and contexts.

Box 2.5. Research-backed tools that harness AI to support students with speech impairments

AI Screener and Orchestrator by AI4ExceptionalEd

With the goal of improving learning outcomes for children with speech-language impairments and relieving the load on speech-language pathologists (SLPs), the AI Institute for Exceptional Education is building two AI tools: the AI Screener and the AI Orchestrator. These evidence-based tools will facilitate universal speech and language screenings, provide SLPs with tools to streamline intervention planning, resource preparation and progress monitoring, as well as tailor interventions to individual needs of students as early as possible (Hadley and Xiong, 2023[104]).

The AI Screener (see Figure 2.5) records a child's speech in structured screening tasks and/or during social interaction in a classroom, then automatically compares vocabulary, sentence structure and speech sounds with developmental expectations. Results can help parents decide whether they seek a more comprehensive SLP evaluation. Speech data from children from various cultural-linguistic backgrounds will be used to train the AI modules, develop the AI tools, and evaluate the team's research progress (Hadley and Xiong, 2023[104]).

The AI Orchestrator (see Figure 2.5) will provide targeted interventions for children who have been identified as needing support through three AI-enabled components (Hadley and Xiong, 2023[104]):

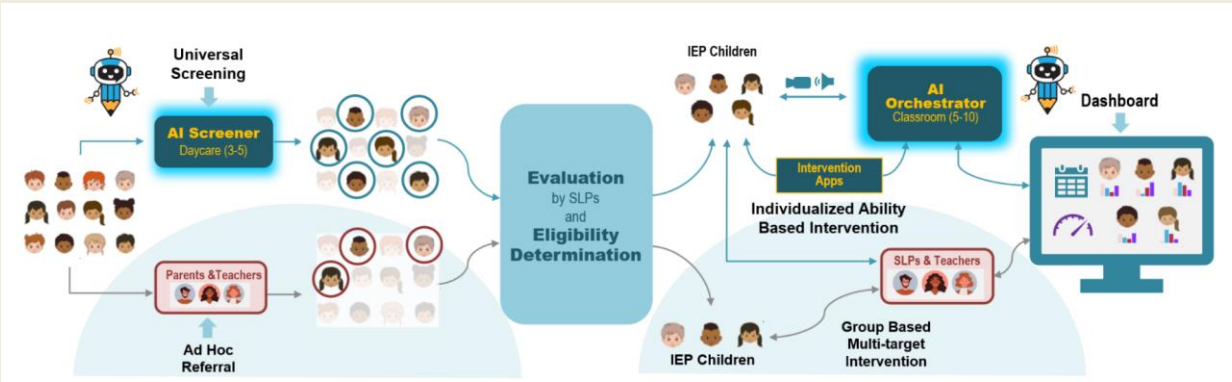
1) Knowledge-based resource that offers evidence-based information (e.g. intervention approaches, therapy materials and progress monitoring metrics) based on a child's age, disability and areas of speech and language need;
2) Intervention recommender that suggests tailored intervention methods for SLPs to implement, based on engagement, response and planning data from therapy sessions. AI will also generate session notes and progress reports for SLPs; and
3) Novel AI-augmented intervention methods and materials to support children's classroom learning.

They will partner with schools and early childhood classrooms to collect data, conduct pilots and validation studies, and offer AI camps for students, hands-on demos and informational seminars (University of Buffalo, 2023[102]). Regarding the validation studies, they have three main goals: 1) establish whether the AI Screener delivers similar or more accurate results when compared with an expert SLP screening; 2) establish whether or not the AI orchestrator can choose the appropriate intervention plans for individual students, which will be reviewed by SLPs for validation; and 3) investigate the long-term effectiveness of the interventions by conducting a school year-long pilot test to measure approximal, distal and academic outcomes at different points in time (Ibid.).

The data are considered sensitive because children with SEN constitute a vulnerable research population. Their data collection and research protocols will thus be vetted thoroughly by the review boards at University of Buffalo and other partner institutions. These boards will consider the degree of risk inherent in the proposed research, the methods to obtain consent by students and parents/guardians, as well as the necessity for collecting any of the data, procedures for safeguarding the data and research protocols for regulatory compliance (University of Buffalo, 2023[102]). All data will be de-identified (including masking any personally identifiable data), stored on secured servers and only shared with approved researchers. They will also require all participating researchers and students receive ethics and data compliance training about the importance of data privacy and security (Ibid.).

The institute's interdisciplinary team comprises speech and language researchers, special educators, AI technologists and human-centered design experts, in addition to over 30 faculty members across nine universities and an external advisory board (Hadley and Xiong, 2023[104]; University of Buffalo, 2023[102]). Experts on the team will seek feedback from SLPs, parents, educators, school administrators, and caregivers on the AI technologies as they are built to ensure a human-centered AI design (Ibid.). Speech-language associations will also help train SLPs to use these tools.

Figure 2.5. Overview of the AI Screener and AI Orchestrator implementation plan



Source: University of Buffalo (2023[102]), NSF AI Institute for Transforming Education for Children with Speech and Language Processing Challenges, https://www.buffalo.edu/ai4exceptionaled/research.html (accessed on 13 January 2025).

Voiceitt

Partially funded by the EU's Horizon 2020 programme, Voiceitt is an accessible and inclusive augmentative alternative communication (AAC) tool for communicating with others, developed with speech-language pathologists and people with speech disabilities (Voiceitt, n.d.[103]). Their goal is to help improve access for people with non-standard speech to education, employment, healthcare and entertainment.

Voiceitt comprises advanced machine learning techniques and a proprietary database of non-standard speech to differentiate between indiscriminate sounds that are unintelligible and standard speech systems (Costanzo et al., 2023[105]). This "discrete" speech recognition is customisable, language-independent, and can be used across different technologies for user-specific speech (Ibid.). The user must create and maintain a bank of their own voice by saying words, phrases and sounds, which allows it to be calibrated to the unique needs of that user. The tool can also learn as individuals use the application. Voiceitt provides three AI-enabled modes:

1) Speak: speech-to-speech for communicating with others. Users can say a word/phrase and then the app will say it aloud in a clear computerised voice.
2) Dictate: speech-to-text allows users to tell a story and the tool dictates it onto the computer.
3) Integrations: automatic closed captioning during video conferencing.

Voiceitt, in collaboration with the Karten Network, conducted user testing with individuals with atypical speech in the UK and Ireland over a three-month period. Semi-structured interviews and informal feedback from participants, their families, and support teams led to improvements to the interface and functionality, such as the introduction of faster voice training, simplified navigation, gamification features and switch access (Howarth et al., 2024[106]).

The company also developed a Talkitt application to support communication for children with Down syndrome (Costanzo et al., 2023[105]). It uses Voiceitt's software to translate in real-time unintelligible sounds into clear words for individuals with Down syndrome who have severe speech impairments (Ibid.). A group of 34 individuals with Down syndrome (5-28 years old) in Italy beta tested the application for six months. Results showed that users improved their linguistic abilities in terms of their speech and vocabulary (although more research is needed to understand this relationship), as well as global adaptive abilities in response to social demands of their environment (Ibid.).

Mobility impairments

Mobility impairments can obstruct individuals' access to physical spaces and educational activities, such as those that involve typing on a keyboard or using a mouse (Brussino, 2020[22]). Examples of impairments include upper or lower limb loss or disability, manual dexterity, and disability in co-ordination with different organs of the body (Ibid.). These impairments may be due to diseases, accidents, and congenital disorders (Ibid.). Due to the diversity of mobility impairments and comorbidities, as well as variations in labelling across countries, it is difficult to estimate the global prevalence.

Without the necessary support and assistive tools, individuals with mobility impairments face challenges in education, employment, health and social spheres (World Health Organization, n.d.[107]).

There are many digital assistive technologies that can support students with mobility impairments, including robotics (e.g. exoskeletons to regain control of various parts of the body, such as Emovo[6]), virtual field trips using augmented reality/virtual reality that allow students to explore inaccessible places such as historical sites, as well as digitally simulated environments that power wheelchairs (Mitra, Lakshmi and Govindaraj, 2023[108]).

In contrast, there are few AI-enabled tools that aim to support students with mobility impairments. Several assistive technologies exist, but they have not been evaluated for use specifically in the context of education. Hands-free computing allows individuals to control devices through voice commands which can expand access to digital educational content for those with impairments that affect fine motor skills, as well as learning disabilities. Software tools exist, such as Dragon by Nuance[7] and Braina[8]. Going beyond voice control, AI tools can facilitate individuals controlling their devices through gestures and eye gaze technology, such as the devices and software provided by Tobii Dynavox[9]. A feasibility study in Chinese Taipei investigated the effectiveness of eye-gaze technology for parents, teachers and therapists to support students with severe motor and communication impairments (Hsieh et al., 2023[109]). The results show that teachers and parents recognised the benefit of using the technology to enhance communication and understanding of the student in their learning and communication (Ibid.). Although AI presents promising opportunities for supporting students with mobility impairments, empirical research and funding in this area are still in their infancy, making concrete advancements difficult to achieve at this stage.

AI tools for mental health disorders

Autism Spectrum Disorders

ASD comprise a diverse group of conditions related to brain development, characterised by some degree of difficulty with social interaction and communication, as well as atypical patterns of activities and behaviours (World Health Organization, 2023[110]). The needs and abilities of individuals with ASD vary and can evolve over time (Ibid.). Depending on where the conditions lie along the spectrum, some people can live independently while others deal with severe impairments and require care and support their whole life (Ibid).

The World Health Organization (2023[110]) estimates that around 1 in 100 children has ASD. Impairments in communication, social interactions and cognition can significantly disrupt daily functioning, developmental progress and educational and social outcomes for these children (World Health Organization, 2014[111]). It can also place considerable emotional and economic strain on families, especially in regions with limited access to essential health and social care services (Ibid.). Depending on the country, the unemployment rate can be as high as 85% for individuals with ASD (Welker, 2023[112]). In terms of societal costs, a study from 2020 estimates the cost of ASD in the United States will rise by 2029 to USD 11.5 trillion , assuming a static rate of increase in ASD prevalence, or USD 15 trillion , assuming current average rate of increase per decade (Cakir, Frye and Walker, 2020[113]). On an individual and societal level, it is crucial that students with ASD receive the support they need to thrive.

Digital technologies are employed by students with ASD to help with communication, learning and everyday tasks. Example tools include digital timers, online learning environments, augmented reality and virtual reality systems (e.g. Floreo[10]), personal digital assistants, voice-output communication aids, and touchscreen technologies that enhance communication and vocational learning (UNESCO, 2020[114]; Rice et al., 2015[115]; Wang et al., 2023[116]; Forsström, Njå and Munthe, Forthcoming[42]). However, challenges such as usability constraints and limited scalability highlight the need to optimise these technologies for more effective use.

For supporting students with ASD, AI-enabled tools have been used to personalise feedback, provide real-time support and foster communication and social skills, a primary challenge for many individuals with autism (see Box 2.6 for detailed examples). Socially assistive robots are one example. In an ambitious research study, an AI-enabled socially assistive robot called Kiwi helped 17 children with ASD improve their math and social skills (Clabaugh et al., 2019[117]). Other robots have also been used in research initiatives exploring how they can support children with ASD, such as Kaspar[11], QTrobot[12], NAO[13], and Pepper[14]. It is important to note that using robots has several limitations, among which are high costs. Available research studies have small sample sizes (which is particularly concerning given the heterogeneity of autism spectrum presentations) and are limited to specific contexts (e.g. special education schools).

Another example, ECHOES, asks students to practice social communication skills by carrying out learning activities set in a magical sensory garden through touch, with help from an autonomous virtual agent that acts as both a peer and a tutor (Bernardini, Porayska-Pomsta and Smith, 2014[118]; Good, 2021[5]).

These AI-enabled tools are products of research initiatives that have yet to be implemented at scale. This partly stems from the complexity of ongoing development efforts, which necessitate the use of advanced AI techniques to detect patterns and offer tailored tools for the very diverse behavioural patterns observed in children with ASD. This is also influenced by the requirement for extensive datasets to train AI models, which are challenging to acquire due to privacy concerns as well as the ethical considerations of working with vulnerable research populations.

Box 2.6. Research-backed tools that harness AI to support students with ASD

Socially Assistive Robot, Kiwi, by USC Viterbi's Interaction Lab

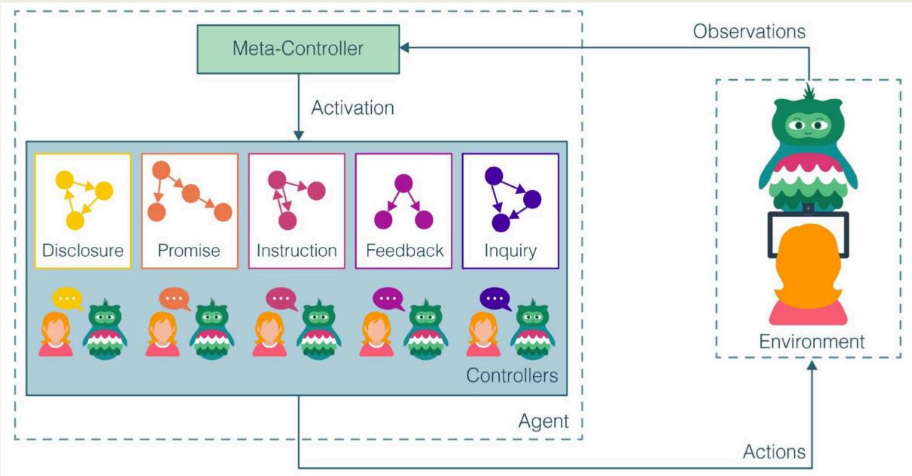
A research team from the Interaction Lab at the University of Southern California and with collaborators from Yale University, Stanford University and MIT developed Kiwi, a green bird-like, gender-neutral robot, to support students with ASD. With funding from the National Science Foundation, the initiative began in 2012 to create a socially assistive robot (SAR) that could be present in households for children to practice in between therapy sessions and school (USC Viterbi, 2020[119]). The research team introduced Kiwi into the homes of 17 children (aged 3 to 8) for 30 days (Clabaugh et al., 2019[117]).

The variability in symptoms of ASD and their severity presents significant challenges for machine learning techniques to identify suitable patterns to respond to atypical responses observed in children with ASD (USC Viterbi, 2020[119]; Jain et al., 2020[120]). Considering data privacy issues, the research team developed a sophisticated method to use only the data they had from participants, and to strike a balance between identifying useful information from data from each child versus from the others in the group (Ibid.). The robot personalises learning through Reinforcement Learning (RL), a goal-based approach where each user action produces a reward representing progress towards the goal. As students interact with the robot, the RL method populates a unique, personalised strategy that can help students make progress based on their behaviours (Clabaugh et al., 2019[117]). Considering the month-long intervention, the approach must ensure the robot can provide personalisation according to these long-term goals. The team therefore created the hierarchical human-robot learning (hHRL) framework that controls the robot (see Figure 2.6). Student actions are sent to a "meta-controller" which decides the appropriate "lower-level controller" to activate based on the state of the intervention. The lower-level controller results in an action by the robot related to:

- instructions (i.e. get the user to do something that might generate progress toward the goal);
- promises (i.e. commitments made for performing future actions that aim to motivate the user);
- feedback (i.e. beliefs expressed to the user about their past and current interactions);
- disclosures (i.e. beliefs expressed to user about the robot's past or current self); or
- inquiries (i.e. get the user to express some truth).

In addition to personalising the robot's response, the system also personalises the level of challenge and feedback based on student data.

Figure 2.6. Hierarchical framework for human-robot learning (hHRL)



Source: Clabaugh, C. et al. (2019[121]), "Long-Term Personalization of an In-Home Socially Assistive Robot for Children With Autism Spectrum Disorders", Frontiers in Robotics and AI, Vol. 6, https://doi.org/10.3389/frobt.2019.00110.

Through a mixed method approach with multi-modal data collection (video, audio and performance data), the results showed that the robot could detect a child's engagement with 90% accuracy (Jain et al., 2020[120]). Assessing skill development thanks to a pre-test and two post-tests (last day and one month after the intervention), they found that all participants exhibited sustained progress in their math skills, with the majority (92%) also showing enhancements in social skills (Clabaugh et al., 2019[117]).

ECHOES

The ECHOES learning environment offers opportunities for students with ASD (aged 4 to 7) to explore and practice social interaction skills, such as attention sharing, turn-taking, initiating and responding to interactions (Porayska-Pomsta, n.d.[122]). Children work through both exploratory, open-ended activities and closed tasks set in a magical garden by interacting with peculiar-functioning objects via a large multi-touch screen (Good, 2021[5]). Key to the experience is the intelligent agent, Andy, who explains activities, offers support and models initiation and response behaviours to the child, such as turn-taking (Ibid.). The experience follows a SCERTS model of Social Communication, Emotional Regulation, and Transactional Support (Bernardini, Porayska-Pomsta and Smith, 2014[118]).

ECHOES is equipped with an intelligent agent that is made up of an AI-enabled autonomous agent (Andy), a pedagogic component, a social-communication component and a practitioner control panel (Bernardini and Ka´ska Porayska-Pomsta, 2013[123]). Andy is powered by an AI agent architecture that comprises a planning mechanism and an affective appraisal system. This architecture provides reactive capabilities to ensure Andy is responsive to the child's behaviours, cognitive capabilities to provide the child with goal-oriented activities and social-emotional competence to help the child develop social skills. For each learning activity, the pedagogic component has an initial state of the environment and relevant goals (based on a user's profile and their interaction history), which it gives to the planning mechanism. The social-communication component attaches social meaning to the child's actions. Blending human and artificial intelligence, practitioners integrate observational data about children's affect, which is fed to the pedagogical component to help personalise the experience. Through a control panel, the practitioner can also choose the activity, duration, and sequencing of activities, as well as prompt the agent to perform certain actions. The pedagogic component can receive input from the child model so that it can intervene if the interaction diverges from the goals of the session.

Originally, the project intended to also develop an AI model that could estimate in real-time a child's cognitive and affective states to inform the agent's next action and reaction to the child's needs. However, it was too difficult to collect reliable eye-tracking and touch data because the children were allowed to move around the room naturally (Bernardini and Ka´ska Porayska-Pomsta, 2013[123]). The project thus created a way for practitioners accompanying the child in using ECHOES to play a key role in the learning experience, as described above (Ibid.).

The interdisciplinary project team combines expertise in psychology, artificial intelligence, human-computer interaction, technology-enhanced learning and autism intervention (Porayska-Pomsta, n.d.[122]). They sought feedback on the design of the experience in the development and testing phases from a wide range of stakeholders, including children with ASD (Good, 2021[5]). Collecting feedback from children with ASD required a slightly different method to interviews or focus groups; instead, they observed the students as they interacted with design prototypes (Ibid.). One of these sessions informed the final implementation design – the inclusion of a human practitioner in the room because interactions that children were having in the game-based learning activities led to spontaneous social interactions between the child and the practitioner (Alcorn et al., 2011[124]).

A study conducted in five schools in the United Kingdom explored the efficacy of the ECHOES environment to facilitate "low functioning" autistic children's ability to engage in social interaction (Porayska-Pomsta et al., 2018[125]). Nineteen children with ASD (aged 4-14) played with ECHOES for 10 to 20 minutes several times a week for eight weeks. Results showed a significant increase in spontaneous initiations to communicate with both the human practitioner and the virtual agent, and over time, children responded more to the human compared to the agent (Good, 2021[5]; Bernardini et al., 2012[126]). These findings highlight the potential of designing technology-enhanced experiences that are engaging, open-ended and adaptive enough to inspire students to demonstrate their abilities. Additionally, it points to the potential educational value of integrating learning technologies into the classroom to foster social experiences within and outside of the technology itself (Ibid.).

Note: Within the sample of autistic children who participated in the UK study, many had learning difficulties (confirmed by the administered pre-test) and had been assessed as developmentally delayed (Porayska-Pomsta et al., 2018[125]). According to the definitions of language ability in SCERTS, many of the children were at the social partner stage (i.e. uses fewer than three words/phrases referentially, regularly, with communicative intent) or the language partner stage (i.e. using more than three, but less than 100 words/phrases referentially, regularly, with communicative intent; Ibid.).

Attention-Deficit Hyperactivity Disorder

ADHD is a neurodevelopmental disorder characterised by a persistent pattern of inattention and/or hyperactivity-impulsivity lasting at least six months, with onset in early to mid-childhood, and a severity that exceeds typical age-related variations, significantly impairing academic, occupational, or social functioning (Mezzanotte, 2020[127]).

According to the Institute of Health Metrics and Evaluation, ADHD occurs in 2.9% of 10-14 year olds and 2.2% of 15-19 year olds (World Health Organization, 2024[26]). ADHD impacts students' ability to function effectively in school, which can be partly explained by factors such as challenges in executive functions, like working memory, planning, organising and shifting (Ibid.). These students are more likely to have failing grades, higher absenteeism, higher grade retention in primary school and are at greater risk of dropout from upper-secondary education and lower post-secondary enrolment compared to their peers without ADHD (Mezzanotte, 2020[127]). They also encounter social and occupational challenges related to a lack of self-regulation, disorganisation and competitiveness (Brussino, 2020[22]; Mezzanotte, 2020[127]). Adults with ADHD are less likely to hold full-time employment compared to adults without ADHD (Ibid.).

Digital tools such as augmented reality (AR) have proven effective in supporting students with ADHD by capturing their attention and enhancing teachers' ability to deliver instruction. AR can also facilitate understanding of concepts, boosts motivation to participate in the learning process and promotes the development of problem solving and collaboration skills (Gottschalk and Weise, 2023[3]). Assistive technology can help these students maintain their focus and regulate emotions. For example, the application, CoolGraig, allows parents and teachers to set regulation goals for children to complete, earn points and exchange them for rewards (Good, 2021[5]; Doan et al., 2020[128]). Digital games can also support emotional regulation. For example, the Danish game, Chillfish, engages students in breathing exercises using a respiration-based controller to instruct a virtual fish (Mezzanotte, 2020[127]; Sonne and Jensen, 2016[129]; Good, 2021[5]). These digital tools do not come without concerns – students were skeptical about their effectiveness, acceptance by others, and personal data privacy (Ibid.). Children with ADHD also have more difficulties turning off games and moving to a different activity (Mezzanotte, 2020[127]).

AI has been purposefully integrated into existing tools to support students with SEN (including ADHD), while in others the support of ADHD is a by-product of the tool. Aligned with the former application, AI-enabled functionalities integrated in digital interfaces can help students with ADHD stay engaged and grasp more complex concepts. For instance, UNICEF's Accessible Digital Textbooks offer the option for students to shorten text passages, visually represent words/concepts and access simplified explanations (see Box 2.4). In this context, AI makes the transformation of content more efficient and effective. Aligned with the latter application, generative AI tools (e.g. ChatGPT) are credited with supporting individuals with

ADHD on educational and everyday tasks, such as staying on track for a school assignment, decomposing a task into multiple steps and reducing procrastination. In a survey of teachers conducted in England (United Kingdom), one educator expressed that GenAI tools helped students with ADHD overcome the "starting paralysis" they experienced with some tasks (UK DfE, 2024[130]). However, these tools require the use of computers that often come with more distractions, which can in turn impact the concentration and learning of students with ADHD (Mezzanotte, 2020[127]).

Another potential use of AI is for ADHD screening. There have been recent attempts to harness virtual reality and artificial intelligence to aid diagnosis of ADHD (Oh et al., 2024[131]). However, research from the United States highlights that women and minorities are often underdiagnosed or misdiagnosed, resulting in unmet or inappropriate care (Chung et al., 2019[132]; Fairman, Peckham and Sclar, 2020[133]). Additionally, younger children in a class – those born just before the school entry cut-off – face a higher risk of being diagnosed and treated for ADHD (Mezzanotte, 2020[127]). It is important to ensure the algorithms and training data underpinning ADHD screening systems do not exacerbate these biases.

The use of AI may be beneficial for identifying and supporting students with ADHD. However, further research is needed to assess the impact of generative AI tools like ChatGPT on students with ADHD, as well as large-scale trials to assess the feasibility and accuracy of AI-based diagnosis.

Taken together, the examples described in this section demonstrate that AI systems and techniques offer some promising opportunities for supporting students with SEN. However, they also highlight a plethora of risks and evidence gaps that should be dealt with before tools like these are used by teachers and students with SEN. These are discussed in Section 3.

3 Risks and limitations of AI tools for students with SEN

Perceptions of AI tools for students with SEN

Before presenting the risks and limitations, it is useful to examine how AI tools are used and perceived by different education stakeholders. However, little information currently exists on how AI tools may be used systematically by teachers and students with SEN. In the absence of these data, there are some recent surveys that can provide context for how teachers, education leaders, parents and students view the use of these tools. They highlight both benefits and risks.

In the United Kingdom, some teachers reported that generative AI increased student engagement and provided better support for students with SEN by facilitating the adaptation of the learning content, such as by developing worksheets for students with SEN so they can progress at their own pace (UK DfE, 2024[130]). In Norway, teachers recognised that AI helps teachers and students explore different genres and create various artefacts, such as advertisements and informative material in a marketing class (Elstad and Eriksen, 2024[134]). In the United States, authors of a recent report surveyed a nationally representative sample of teachers and districts on using AI tools in K-12 classrooms. They found that of the teachers who used AI in general, 51% reported using AI tools to support students with learning differences (Diliberti et al., 2024[135]).

The reliability of Generative AI tools is contingent on the quality of their underlying datasets, particularly given the prevalence of inaccurate and non-evidence-based material online. General LLMs may incorporate such material when generating content and recommendations, raising concerns about the accuracy and appropriateness of their outputs for students with SEN. While advancements in evidence sourcing (e.g. providing references in generated responses) improve transparency, they do not ensure teachers or parents will systematically verify the information before applying it. This presents a risk, as inaccurate guidance could lead to ineffective or even detrimental educational decisions. In contrast, AI-enabled tools such as the early literacy chatbot by LEVI's AI Lab mitigate this risk by relying on a rigorously vetted dataset, the What Works Clearinghouse (see Box 2.1). This approach, which involves trained and certified reviewers assessing and summarising research studies that meet stringent standards, ensures that generated outputs are evidence-based and aligned with best practices in education (Institute of Education Sciences, n.d.[55]).

While some teachers recognise the potential benefits of AI in education, others raise concerns around the effectiveness of AI tools, such as generative chatbots, for learning. In the context of a teacher survey in Norway about students' use of a school-relevant chatbot, a common concern among the 236 teachers was being able to understand the ability of students to think independently, comprehend and apply knowledge without relying on technology, including AI (Elstad and Eriksen, 2024[134]). They also point to a lack of guidance from relevant leadership.

> *"It's a Catch-22 situation. It's possible that pupils can learn something by using it, but the temptation to cheat and skip the actual learning will always be present. I miss a manager or an authority or politicians who say we should close the web and help us with that. We need AI-free spaces where pupils can really learn. But as of*

> *now there is no off button because people think new technology is something that cannot be avoided, like gravity." (ibid, p. 13)*

In a survey that collected views from over 100 parents and students in England (United Kingdom) on their attitudes towards the use of AI in education, participants voiced that, in the current education system, access to quality AI tools would be limited to schools that could afford it. They felt this would exacerbate existing inequalities in the education system, as well as in the labour market and society (UK DSIT and UK DfE, 2024[136]). These perspectives highlight the need for evidence-based decision making when introducing or maintaining AI use in education.

Risks of developing and using AI-enabled tools

Ethical concerns around privacy have been raised regarding the use of AI tools with students, especially with those who have SEN. Some of the tools reviewed in Section 2 harness AI to personalise educational content or functionalities to individual students, which can require the collection and processing of large amounts of their data. These data, including sensitive information such as biometric data (e.g. eye-gaze and facial recognition), could be misused or commercialised (Varsik and Vosberg, 2024[13]).

Furthermore, students cannot be expected to give informed consent about the use of their data, especially in AI contexts. They may have a limited understanding of how recommendations and predictions made by AI based on their data can impact their lives (Holmes et al., 2022[15]).

Accountability for any harm that is caused from educational tools being exclusionary, discriminatory or biased is also unclear. In fact, parents of school-aged children in the United Kingdom expressed their concerns about AI in education, particularly regarding its accountability (77%) and privacy and security (73%) (Holmes et al., 2022[15]). Incorrect or biased guidance from AI chatbots can have long-lasting consequences which can also be difficult to rectify (Varsik and Vosberg, 2024[13]). Evidence reveals that content produced by LLMs contains bias against women, homophobic attitudes and racial stereotyping (UNESCO and IRCAI, 2024[137]).

AI algorithms can also reinforce biases, thereby perpetuating inequalities and discriminatory practices against specific groups (Baker and Hawn, 2021[138]). This can occur through training data that reflect societal biases (e.g. gender, racial/ethnic) or through the unconscious or conscious biases of algorithm developers (Ibid.). For students with SEN who may demonstrate atypical behaviours like is the case for ASD or who have irregular speech as is the case for speech impairments, algorithmic bias can lead to allocative harms (e.g. inaccurate predictions about needs or diagnoses) and representational harm (e.g. stereotyping and underrepresentation of specific groups) (Baker and Hawn, 2021[138]). Importantly, special education needs intersect with race/ethnicity, gender, sexual orientation and socio-economic background (Varsik and Gorochovskij, 2023[139]). Individuals with SEN are thus at a higher risk of being negatively impacted by compounded biases in algorithms, such as in automated diagnostic systems for ASD (Whittaker et al., 2019[140]). An illustrative example is a study conducted in the United States that found racial bias in facial recognition systems. The study evaluated 189 software algorithms for facial recognition systems from 99 developers. They found the highest rates of false positives in relation to Indigenous peoples (GEM Report UNESCO, 2023[141]).

Another risk is that AI solutions are developed because they are technically possible, rather than resulting from real needs expressed by the intended users before or during the development phase. This highlights the importance of research and user feedback that involves students with SEN and other education stakeholders (e.g. educators, family members, counsellors). For example, the research team involved in the ECHOES project understood the importance of having a facilitator in the room when they asked students with ASD to test the prototypes (see Box 2.6).

Further, a lack of interdisciplinary expertise within a research and development team risks to release AI tools that do more harm than good. Education experts may become quite familiar with artificial intelligence compared to others in their field, but they still might not understand risks inherent in software architecture, data pipelines and AI techniques for the privacy and protection of student data. The same goes for experts in inclusive education without which edtech developers might create tools that exacerbate harmful values, such as tools framed in techno-ableism. The interdisciplinary team developing the AI Screener and Observer serves as a great example for how to build AI tools with adequate expertise (see Box 2.5).

The environmental cost of harnessing AI should also be a significant factor to consider when developing tools with AI and making decisions about using AI in educational contexts. Large datasets are necessary for training AI models in the creation, selection and calibration of models and algorithms (Hodgkinson, Jennings and Jackson, 2024[142]). Increasing the need for more data adds to the already rapid expansion of global data creation volume, which is predicted to continue in the foreseeable future (Ibid.). For AI computing (i.e. training of AI models), it is estimated that global computation for AI will require comparable amounts of annual electricity used by countries like Austria and Finland by 2026 (Ibid.). For example, a single LLM query uses an estimated 2.9 watt-hours of electricity, compared to 0.3 watt-hours for a regular internet search (United Nations Environment Programme, 2024[143]). Training AI models can also result in the evaporation of vast amounts of fresh water into the atmosphere as part of data centre cooling processes (Ren and Wierman, 2024[144]). While further evidence is required, projections suggest that by 2027, the global demand for water from AI use could surpass the United Kingdom's total annual water usage in 2023 (United Nations Environment Programme, 2024[143]). These estimations are concerning and point to unsustainable consumption as renewable energy sources cannot respond to this level of consumption (Hodgkinson, Jennings and Jackson, 2024[142]). With increasing data-related CO_2 emissions, AI models are becoming a large proportion of global emissions (Ibid.). Moreover, the environmental impacts of AI are not evenly distributed, with certain regions and communities bearing a disproportionate burden (Ren and Wierman, 2024[144]). For example, Google's data center in Finland ran on 97% carbon-free energy, whereas in Asia, its data centers ran on 4-18% (Ibid.). Several practices to reduce the burden exist, including building efficient AI model architectures, optimising algorithms to speed up AI training and inference, and responsible data disposal (United Nations Environment Programme, 2024[143]; OECD, 2022[145]; Ren and Wierman, 2024[144]). Advancements in AI technologies may improve energy efficiency in some areas, however, there are many variables to consider across the complex AI lifecycle (e.g. response lengths, architecture design, increased use) when determining the environmental sustainability of an AI tool.

Another risk is equitable access to these technologies, assuming they are indeed deemed beneficial for integrating into educational practice based on comparative and cost-benefit analyses. The financial cost of some AI tools, such as educational games, virtual reality and augmented reality can widen resource gaps (Varsik and Vosberg, 2024[13]). Schools that can afford to pay proprietary tools may be forced into accepting price increases because their educational practices rely on the tools, or schools who can no longer afford it will put additional strains on teachers and students to adapt to new processes and potentially, new tools. Tools that rely on LLM providers are also susceptible to cost increases, especially considering their price trajectory since their public release. These costs may even impact parents and/or students, depending on the funding model, which can disadvantage further students from disadvantaged backgrounds.

Finally, a fundamental concern in the adoption of AI tools lies in the risk of perpetuating techno-ableism – the assumption that technology should render individuals able-bodied and neurotypical (Shew, 2020[146]). This perspective marginalises those who do not conform to normative standards and disregards their autonomy and lived experiences. The belief that all individuals require a "fix" to meet societal expectations fails to acknowledge the inherent value of human diversity and overlooks structural barriers that contribute to exclusion (Varsik and Vosberg, 2024[13]; Smith and Smith, 2020[147]). Using AI tools framed in techno-ableism in educational contexts can inculcate a harmful view of disability in students, which can have lasting repercussions on equity and inclusion in education and beyond (Ibid.). This review has intentionally excluded several AI tools that promote normative "correction" of students with SEN, underscoring the critical need for participatory design processes. Individuals with SEN and disabilities must be meaningfully engaged in the development and evaluation of digital technologies to ensure that these tools reflect diverse needs and preferences rather than confirming to narrow conceptions of ability.

Current limitations of the evidence that AI tools support students with SEN

There is an increasing number of AI tools that claim to support students with SEN. However, the empirical evidence is lacking (UK DfE, 2024[130]; Varsik and Vosberg, 2024[13]). This review confirms a gap in robust research on the effects of AI-based tools on students with SEN. The tools reviewed above have already gathered some initial positive evidence and/or have concrete plans for how they will do so. However, most of the tools reviewed have still not sufficiently assessed whether the AI tools improve the learning and well-being outcomes of students with SEN and their efficacy across different cultural contexts. This is largely due to limitations in the research methodologies used to assess these tools, such as small sample sizes, underrepresentation of students with SEN, and lack of robust methodologies (e.g. randomised controlled trials, longitudinal studies). For instance, some tools make claims on the effectiveness of their tool for students with SEN without focusing on these students in impact studies.

Considering the various risks related to algorithmic bias outlined above, identifying when an algorithm or model is biased against students with SEN could help avoid harmful use of AI tools in educational contexts and beyond. Although there is increasing research on algorithmic bias, the research does not focus sufficiently on students with SEN and learners from disadvantaged backgrounds (Baker and Hawn, 2021[138]).

The review of AI tools for different types of needs shows that they mostly attempt to improve on non-AI tools that already existed. More research is needed to evaluate whether the marginal benefits of using AI are justified given the risks of AI in terms of data misuse, financial and environmental costs, and biases. Education stakeholders need this type of comparative evidence to make informed decisions about which tools they invest in and integrate into their educational practice, particularly for those that involve students with SEN.

As pointed out several times in this section, there is also a lack of comprehensive data on global prevalence rates of SEN. This data gap could delay the development and implementation of technologies designed to support individuals with SEN. Ideally, the accessibility of assistive technologies should not depend on the size of the population needing or receiving diagnosis for support. However, a lack of clarity on demand complicates resource allocation and financial investment in such innovations. If the principle that every individual has the right to assistive technologies is upheld, prioritising research to assess needs and leveraging advanced tools, including AI, becomes imperative. Notably, there is a strong case for assessing the extent to which tools designed for all students can also effectively support students with SEN. This approach may reduce the reliance on precise prevalence figures, particularly for disabilities experienced along a broad spectrum such as dyslexia, where personalised support strategies can respond to a wide range of learners. Such a cost-benefit analysis could also incentivise the development of more universally inclusive tools that are responsive to the varied needs of all learners.

Initiatives from the health field for sharing secure data for secondary analysis, protecting the rights of individuals in research and making the use of AI more transparent can serve as inspiration for the education field (see Box 3.1).

Box 3.1. Promising initiatives from the health field

Given the risks and limitations regarding AI in education as outlined in this section, it can be useful to look to other fields who face similar challenges in relation to data sensitivity and fast-paced technological innovation trends, such as health and medicine.

Supporting further research through secure sharing of secondary data

An international, multi-stakeholder initiative, RWE4Decisions, brings together policy makers, insurers, health ministries, regulatory agencies, clinicians, patient groups, academic experts/researchers, and industry to agree on what real-world data to collect from highly innovative technologies based on the principles of collaboration and transparency (RWE4Decisions, n.d.[148]). The evidence created from these data can facilitate rapid decision making around new technologies that are released to the market early to benefit patients but only limited evidence from traditional clinical development programmes is available. This type of public-private collaboration at the international level can establish data sharing and open data standards that can help create evidence needed to make decisions about innovative AI technologies that are released into the education field.

Protecting the rights of students with SEN in research

The Accelerating Clinical Trials consortium in Canada works with research networks across the country to ensure all humans and their rights are protected and respected in health research by following the principles of equity, diversity and inclusion (Accelerating Clinical Trials, n.d.[149]). A similar type of consortium could be started for research on AI in education for diverse populations, including students with SEN.

Certification for transparent use of AI

The Coalition for Health AI (CHAI) has established a national network of independent assurance labs of healthcare AI (Beavins, 2024[150]). As part of their certification approach, CHAI is creating an AI model card, sometimes referred to as an AI "nutrition label", that will help set a minimum threshold around disclosure and transparency for AI models based on national health requirements (Ibid.). The model cards are required to state the source of funding, intended use, intended patient population and known risks of the model, among a long list of other requirements.

4 Operational and Governance Conditions for Implementation

Having outlined both the opportunities of AI tools to respond to some of students' special education needs and the associated risks, it is necessary to examine the operational and governance conditions that can ensure effective, ethical, environmentally responsible, and secure implementation of AI tools in education systems.

Co-design and development

The principle of co-design is key. This involves development teams considering the voices of teachers, students with SEN, parents and other educational practitioners in the design and development process to ensure AI-enabled tools address real needs (Cranmer, 2019[151]). Within these groups, teams could benefit from identifying individuals who are technology enthusiasts, but also, and especially, those who hold critical views. This can be achieved through usability studies, piloting tools in classroom settings, and gathering feedback at all stages of development before broader implementation (Spiel et al., 2019[152]). However, development teams may not have access to groups of teachers and classrooms. Institutional programmes that involve researchers, industry, teachers and other education stakeholders could help define an infrastructure for including them in impact research (OECD-Education International, 2023[153]). For example, the American Group of Innovative Learning Environments (AGILE) Network provides a centralised infrastructure to facilitate research, development and evaluation efforts (Leanlab Education, n.d.[154]). The network puts teams developing emerging technologies and conducting research in contact with participating schools and educators to facilitate rapid development cycles (Ibid.). The various members (e.g. public districts, charter schools, individual schools) are intentionally selected to prioritise historically disadvantaged learner communities to combat existing inequities in educational research and development (Ibid.). This type of network could be reproduced in other countries with an additional focus on teachers and stakeholders working with students with SEN. By adopting a collaborative, human-centred approach, AI tools can be tailored to better meet the needs of diverse users while mitigating risks of exclusion or misalignment with educational contexts.

Special-need design is another important consideration for this process. People with disabilities, drawing on their lived experience, can inform how technological systems are built to help people with disabilities achieve their goals, rather than automating these processes on their behalf (Hickman, 2022[155]). Teams could include or consult experts with disabilities and accessibility professionals to ensure the AI tools are useful and reduce biases (Felix, 2023[156]). Similarly, it would be useful for the design of learning environments and experiences that incorporate AI to follow UDL guidelines to ensure they are accessible, inclusive, equitable and challenging for all learners (CAST, 2024[87]).

It is also important for teachers to be "kept in the loop" in the design, development and implementation phases of AI tools. There is potential for AI tools to enhance and support human expertise, but never as a replacement. Involving teachers in decision-making processes can safeguard human agency that is crucial to the effective and equitable use of AI in classrooms. Functionalities can be built into the tools to allow teachers to intervene when needed and be involved in review and approval processes, for example by filtering AI-based recommendations.

Training developers on how to design AI-enabled tools with and for individuals with SEN also plays a pivotal role in achieving these objectives. Non-profit initiatives like the Teach Access programme provide valuable models that can be expanded to AI. This collaborative project between academia and the technology industry aims to integrate accessibility principles into mainstream education for designers, engineers and researchers (Touzet, 2023[83]). Accessibility specialists from tech companies work alongside academic programmes in computer science and innovation design to prepare students to create technologies that inclusively address the needs of diverse populations (Ibid.). Similarly, the Erasmus+ WEAVE project aims to equip post-secondary vocational education and training (VET) providers with resources on accessible web design for students with SEN so they can adjust VET based on the unique needs of learners (WEAVE, 2022[157]; Jeon, 2025[158]). A toolkit developed by the World Economic Forum in collaboration with a diverse team of youth, technologists, academics and business leaders, proposes an AI labelling system that helps companies and tech innovators provide systematic information to users on how an AI-enabled tool was developed considering the user's age, accessibility features, sensors, networks, AI use and data use (World Economic Forum, 2022[159]). It also purports that decisions, recommendations and other outputs coming from AI systems should be understandable to the ecosystem of users, such as teachers and parents. Another good practice is asking scientific and ethics boards composed of experts in SEN, data science and education to review and provide guidance on AI tools (see Box 2.2 and Box 2.5 or examples of how this has been done in practice).

Continuing professional learning

To address the risks associated with AI tools and to create equitable opportunities for all learners, it is vital to equip educators with the knowledge and skills they need to understand and make informed decisions about AI tools. This can be achieved through the integration of critical AI literacy skills into the curriculum of higher education programmes for pre-service teachers, as well as offering continuing professional learning opportunities for in-service teachers. AI training could focus on helping them understand AI techniques, attributes of an AI system (e.g. accessibility, security, sustainability), critically evaluate AI outputs (e.g. recommendations) and how to use AI ethically in their teaching practices (OECD-Education International, 2023[153]). Continuous professional learning can be designed to prepare all teachers to make evidence-based decisions about the use of AI to support students with SEN. One example is a recent initiative to introduce AI textbooks in Korean schools in Mathematics, English, Informatics and Korean for special education. Following concerns from various entities in Korea around privacy, security and well-being of students, as well as a lack of digital skills for teachers, the Korean Ministry of Education postponed the launch of the AI-enabled textbooks (GEM Report, 2025[160]). In response to these concerns, the Ministry has allocated 740$ million to train all teachers in the use of novel digital technologies in the classroom and to implement innovative teaching models that harness AI to enhance student learning for all by 2026 to prepare them for the eventual roll-out of the textbooks (Ibid.).

Coordination of philanthropic initiatives

Coordinating philanthropic initiatives can help establish research, development and innovation systems that effectively align with educational priorities, amplify impact and optimise the use of resources. For example, the Jacobs Foundation is funding two research centres that aim to improve the use of Edtech and AI: 1) the Centre for Learning and Living with AI (CELLA), started by professors at the University of California (Irvine), that prioritises the development of thoroughly researched technologies for education, ensuring their effectiveness and suitability before they are introduced into schools; and 2) Connecting the EdTech Research EcoSystem (CERES), led by Professors at the University of Oulu and Radboud University, which facilitates collaboration of leading scientists in computer science, psychology, neuroscience and education with the EdTech industry to ensure digital tools used in classrooms improve student learning (Jacobs Foundation, n.d.[161]). Similarly, the Nuffield Foundation and the Ada Lovelace Institute in the United Kingdom are collaborating on research into digital and AI technologies used in UK public primary and secondary schools, as well as evaluating the policy landscape and opportunities to fill research gaps (Nuffield Foundation, 2023[162]).

Independent federal agencies could partner with departments of education to increase the impact of funding and drive innovation. For example, the National Science Foundation and the Institute of Education Sciences of the US Department of Education co-funded the National AI Institute for Exceptional Education, led by University of Buffalo and in collaboration with several other universities. This initiative advances AI technologies to improve screening and provide individualised interventions for speech and language challenges (see Box 2.5).

These initiatives exemplify how coordinated funding efforts can advance research into the role of AI and data-driven technologies in education. Such collaborations not only maximise the reach of the research, but also create a cohesive ecosystem that drives sustainable innovation in educational research and practice.

Improvements to research funding mechanisms

> "Even when [AI] applications have research evidence, market failures often prevent them being rolled out more widely." (Holmes et al., 2022[15])

Numerous examples in this review highlight research initiatives that demonstrate ways in which AI tools can support students with SEN in achieving their educational goals. Despite their potential, these initiatives have yet to be scaled widely, likely in part due to funding challenges. Access to financial resources often depends on competitive grant schemes, which typically involve complex, resource-intensive application processes and adherence to specific thematic and procedural requirements. In addition, successful applications must meet rigorous quality and ethical standards, which, while essential, requires time for the development and scaling process. These conditions can hinder the establishment and sustainability of research initiatives within the educational technology landscape. Establishing more flexible and responsive funding mechanisms could help ensure more AI tools in schools are grounded in rigorous evidence and standards.

There are some interesting examples of how foundations and governmental agencies are identifying new funding models that can respond in a more agile manner to innovation, which is particularly interesting for fast-paced fields like AI. For instance, the National Science Foundation (NSF) in the United States announced in 2023 a partnership with the Institute for Progress, a Washington DC-based think tank, to evaluate and improve the efficiency of research funding and support mechanisms (Chawla, 2023[163]). Gaining access to administrative data from NSF, the partnership plans to explore the effectiveness of recent initiatives (e.g. no-deadline policy) and consider ways in which more innovative research could be funded (e.g. "golden ticket" mechanisms; Ibid.). There is potential for this type of research on funding mechanisms to expand to the US National Institutes for Health and to UK research processes (Ibid.). The National Center for Education Research at the Institute of Education Sciences (IES) also launched in 2023 the Accelerate, Transform and Scale (ATS) initiative to invest in rapid, scalable tools to improve education outcomes for all students (IES, 2023[164]). It draws inspiration from advanced research projects agencies

(ARPAs) that exist in various domains of the US federal government, which use findings from traditional research to develop innovative tools (Ibid.). IES is thus supporting interdisciplinary, diverse teams that have innovative ideas that can address important challenges in the education field. The "From Seedlings to Scale (S2S)" programme is particularly interesting because it employs a three-phase investment strategy to nurture transformative ideas as they develop and scale. Phase one consists of a deeper examination of the problem research teams are trying to address and refining the tool (e.g. a product, policy or process) (IES, 2025[165]). Phase two is for developing a fully functional version of the tool. For the most promising tools, a phase three could support evaluating the impact of the tool across multiple settings and contexts with the aim of scaling the tool.

Public-private partnerships

Collaboration among governments, private companies, civil society and other stakeholders (e.g. schools, teachers, parents, students with SEN) can help ensure AI-enabled tools in education are not a replacement of teacher-led instruction and are as effective, inclusive, ethical, sustainable and secure as possible (GEM Report UNESCO, 2023[141]). The Estonian government are planning to launch in September 2025 a pilot phase of a nationwide AI education programme called AI Leap 2025[15]. This non-political initiative will establish a foundation that combines national vision with private-sector innovation to provide teachers and students with AI-based learning applications and the skills they need to use them effectively (Republic of Estonia, 2025[166]). They have started negotiations with technology providers, such as OpenAI and Anthropic, ensuring they meet standards like GDPR compliance (Eestis, 2025[167]). Another example is the AI Centre for Educational Technologies (AICET) that was established by the Singaporean Smart Nation and Digital Government Office and the Ministry of Education with funding from AI Singapore (AICET, n.d.[168]). The Centre is hosted by the National University of Singapore School of Computing and aims to create and implement innovative technological tools that offer pedagogical support (e.g. consultation on integrating AI tools in teaching and facilitating student participation in testing and refining pedagogical innovations; Ibid.). The Tools Competition, a coordinated funding effort financed by the Walton Family Foundation, the Bill & Melinda Gates Foundation, Jacobs Foundation, OpenAI, among others, awards funding to projects that drive innovation in educational technologies (Kucirkova, 2024[169]). Open to edtech innovators, researchers, students and educators who have tools at various phases of development, it aims to advance learning science research that leverages big data to help improve learning outcomes worldwide (Tools Competition, n.d.[170]). One of the evaluation criteria is "attention to equity to support learning of historically marginalised populations" (Ibid).

Public-private partnerships (PPP) can connect technological innovation and AI expertise of private companies with public oversight through funding, regulations (e.g. inclusive practices, ethical standards, sustainable AI infrastructure, security), auditing mechanisms and access to public data (World Economic Forum, 2024[171]). Public entities can hold the private companies accountable for creating high-quality, human-centred and research-backed tools, while also expanding AI expertise across stakeholder groups (Kucirkova, 2024[169]; Saavedra, Barron and Ezequiel, 2024[172]). Moreover, PPPs can facilitate international collaboration that advances knowledge sharing, technology as public goods, investment in technology infrastructure and common ethical standards to allow for flexible scaling (World Economic Forum, 2024[171]). In Finland for example, the AI in Learning project is an ecosystem of companies and researchers that work on various sub-topics, such as ethical challenges and tools (University of Helsinki, n.d.[173]). Hosted by the University of Helsinki, there are research institutions, companies and foreign partner universities that seek out tools and practices that help understand how AI can promote equity and quality learning in Finland and beyond (Ibid.).

These types of partnerships also hold potential for applying non-mainstream approaches to AI development in practice. For example, by drawing on feminist AI, which explores gender and technology at the intersection of race and class, stakeholders can prioritise the creation of "fairer, slower, consensual, collaborative AI" (Toupin, 2023, p. 592[174]). PPPs could focus on developing appropriate datasets for students with SEN, which can contribute to the creation of more transparent, explainable, and equitable AI tools (Selwyn, 2023[175]). At the same time, these efforts can be accompanied by robust data protection and security measures. Safeguards are essential to ensure that sensitive data about students with SEN – such as information about their needs or disabilities – are not misused in ways that could negatively impact their healthcare, employment prospects or privacy (Whittaker et al., 2019[140]). These processes could be further improved thanks to PPPs.

International collaboration

Considering the long road ahead in navigating AI and its role in education, particularly for students with SEN and diverse populations, international collaboration is a necessary step forward. Countries can find ways to share information and research findings on effective tools, such as by creating shared repositories of vetted evaluation research. Defining what "effective" (e.g. improves learning, promotes well-being) means for different types of AI tools is an important first step in this endeavour. Countries could then create and agree to implement common data frameworks to facilitate comparative, longitudinal and international studies. These studies could measure and monitor the impact of specific AI tools on students with SEN, or more broadly follow digital and AI inclusion within and beyond education (Nielsen, 2022[176]). They can also pool resources to create international public goods, such as open-source large language models and AI-based tools that accommodate diverse populations. For instance, the Danish Ministry of Digital Affairs is funding an R&D platform for training, fine-tuning, evaluating and maintaining LLMs for Danish-language contexts (Virenfeldt Kristensen, 2024[177]). The LLMs will be fully documented, open-source, inclusive and culturally attuned (Ibid). Linguistically similar countries could collaborate on developing LLMs for educational use, enhancing efficiency of the process and quality (e.g. minimising biases, ensuring cultural relevance) of the output, as well as reduce the environmental impact. Countries can also work together to create regulation for AI. The European Artificial Intelligence Act (AI Act) is a good example of how coordinated regulation of AI can require responsible development and deployment of these tools in regional areas (European Commission, 2024[178]). It specifically aims to protect people with disabilities and other marginalised groups by preventing discrimination or loss of privacy (Ibid.).

Finally, coordination among international organisations would help ensure the best use of public funding and effective coordination of AI governance. The 44 member countries of the Global Partnership on Artificial Intelligence (GPAI) and the OECD recently announced a partnership with the United Nations Office of the Tech Envoy to coordinate their governance efforts related to AI (Perset and Aranda, 2025[179]). Moreover, the sixth edition of the Athens Roundtable on AI and the Rule of Law examined how international institutions (e.g. OECD, UN, G7, G20, UNESCO, AI Safety Institutes, European AI Office, the Council of Europe, the African Union and France's AI Action Summit) could improve accountability mechanisms for AI governance, addressing gaps and enhancing coordination (Iliadis and Miller Nguyen, 2024[180]).

5 Policy Considerations

The OECD (2023[4]; Boeskens and Meyer, 2025[181]) has collected international comparable data through country surveys that show that rarely at the system level are criteria relating to ethics (e.g. algorithmic bias), environmental sustainability and demonstrated effectiveness considered in the context of procurement for digital technologies. Considering this and the review of AI-enabled tools above, this section discusses policy considerations for designing, selecting and (potentially) integrating AI-enabled tools to support all students, especially those with SEN, to achieve their learning goals. Countries could consider the following four elements when procuring AI tools for students with SEN, as well as conducting and funding research and development activities:

1) **Ethical design and use of AI tools** by adhering to value-based principles of fairness, safety, sustainability, accountability and transparency (see the OECD.AI Principles for Trustworthy AI and the Catalogue of Tools and Metrics for Trustworthy AI[16]: (OECD, n.d.[182]; OECD, n.d.[183])). Ultimately, AI systems are reflections of the biased societies within which AI algorithms are programmed and data sets are created. It is thus important to identify and investigate potential biases in AI algorithms (e.g. historical bias, disability bias) and how different groups may be impacted by their intended use to avoid discriminatory effects (Baker and Hawn, 2021[138]). Researchers and developers can take various steps to increase fairness, such as using relevant datasets that reflect diverse learners and appropriate software tools with proper documentation (Ibid.). Regular fairness reviews and ongoing monitoring of AI models can help mitigate risks and promote equitable outcomes, particularly for students with SEN (Trewin et al., 2019[184]). When designing AI-enabled tools, following Universal Design for Learning guidelines can ensure that all students, including those with potential or unidentified SEN, are provided agency and flexibility to choose their preferred modes of learning (CAST, 2024[87]).

   Given that students with SEN represent a diverse and vulnerable population, ensuring accountability for discriminatory outcomes or harmful guidance arising from the use of AI is essential. Greater transparency about the purposes and aims of AI policy and system development processes, particularly in relation to children, could help hold involved stakeholders (e.g. policy makers, developers, implementors, etc.) accountable for negative actions or impacts (UNICEF, 2021[185]). Developing regulatory frameworks to mitigate risks related to children's data rights, digital security and AI, alongside establishing oversight bodies to handle complaints and monitor children's safety, are key initial steps (OECD, 2023[186]). Private-public partnerships can also strengthen oversight of AI tool development and use through the involvement of responsible public agencies and universities.

   AI tools can be transparent by making it clear how they use AI, the potential benefits for users, as well as the potential risks (UNICEF, 2021[185]). For example, using an AI labelling system like the one developed by the World Economic Forum with various stakeholders to provide systematic information about AI tools, such as how AI and data are used (see Risks and limitations). Scientific and ethics boards with relevant stakeholders (e.g. accessibility experts) can also serve as an important validation step of the AI tools, their intended uses and intended users, such as the one established for School Rebound (see Box 2.2).

The ethical development and use of AI-enabled tools also depend on understanding and minimising their environmental impact, which can disproportionately harm certain regions and communities (Ren and Wierman, 2024[144]). There are promising initiatives to mitigate the energy use of data centers, such as developing large-scale solar farms, purchasing renewable energy credits and replenishing more water than has been consumed (Ren and Wierman, 2024[144]). However, environmental inequity of AI remains, and what is more, data from all stages of the AI cycle are currently sparse. Policy makers can address these measurement gaps by implementing policies that set standards, expand data collections, disaggregate ICT infrastructure datasets, explore a range of environmental aspects (e.g. land system change, transport and end-of-life impacts) and improve environmental transparency (OECD, 2022[145]). They can also ensure continuing professional learning educates teachers and school practitioners about the environmental impact of AI to support their cost-benefit analysis when deciding if, when and how they use AI tools. Finally, curricula can be designed to include environmental modules within AI literacy learning to empower all students to carry out similar cost-benefit analysis.

2) **Robust research and long-term monitoring** of AI-enabled tools that aim to support students with SEN in all their forms - from nascent ideas to fully developed tools. Comparative analysis studies could be conducted to evaluate whether AI tools support students with SEN compared to other digital (non-AI) or non-digital tools. For example, a recent study by the National Foundation for Educational Research (NFER) evaluated the impact of guided ChatGPT use for lesson and resource preparation on the time teachers spend on these activities, compared to other methods that were unassisted by GenAI technology (Roy et al., 2024[187]). The findings of comparative studies can inform improvements that need to be made to the tool, further investment in the tool and potential uptake by teachers and students. Ideally, this evaluative research would be carried out by independent parties absent of any conflicts of interest.

   Introducing cost-benefit analysis into common practice can also prepare education systems to take balanced decisions about investing in and adopting AI-based tools. Internationally comparable indicators could be established, such as the environmental sustainability, financial costs and ethical concerns. For example, using AI for helping students with ADHD to keep track of their tasks may not be the best option considering there are plenty of other non-AI (and even non-digital) tools that can support them and are more environmentally sustainable. However, other uses of AI to overcome specific barriers may be justified.

   More longitudinal research on AI tools for students with SEN is also needed to establish the impact of AI tools on the learning outcomes and well-being of students with SEN, social and emotional skills, teaching practices and broader societal outcomes over time (e.g. social inclusion, civic participation, an equitable and inclusive labour force). Studies could target diverse groups to assess whether the tools are appropriate, effective, and ethical for all students. The impact of this research does not solely depend on the robustness and significance of its findings, but also on its dissemination. To maximise its reach, findings can be shared under an open license and disseminated through well-established international channels (e.g. OECD AI Observatory[17]). More targeted surveys that collect perspectives and attitudes from students with SEN, their parents/guardians, teachers and school leaders would also be useful to provide important nuances to how they view the use of these tools over time. It is important to establish mechanisms that ensure the rights of students with SEN in research studies, as demonstrated by the Accelerating Clinical Trials consortium (see Box 3.1).

3) **Appropriate data protection regulation, data sharing and security practices** for all students, but especially for students with SEN and from disadvantaged backgrounds. Important considerations for data protection regulation include sufficient coverage of different data types, such as biometric data like eye gaze and emotion, and risk mitigation, such as avoiding

commercialisation and building stringent security measures (OECD-Education International, 2023[153]; Holmes et al., 2022[15]). Transparency is also key - informing teachers, parents and students with SEN about their rights (e.g. right to withhold or withdraw consent) and how their data are being used (Ibid.). As part of this process, relevant stakeholders could involve them in the governance and oversight of how their data are used. Continuous monitoring and the evaluation of data security practices in AI tools by governments and education stakeholders can help identify issues early and ensure adjustments are made to protect students' privacy (Holmes et al., 2022[188]). Moreover, public and private investments in open datasets that respect privacy and data protection to support research and development of AI tools can minimise bias and improve the use of standards (OECD, n.d.[182]).

Another issue is that much of the collected data are not used for research. It is useful to draw from examples of productive uses of secondary data in other fields. In the health sector, the focus around data protection and security has shifted from "privacy" to "harm" – under-sharing anonymised data can be just as harmful as over-disclosure of data (Wawrzyniak, 2024[189]). They implement adequate protective measures such as strict anonymisation to share safely secondary data for medical research and health innovation. The RWE4Decisions initiative is a good example of how a multi-stakeholder collaboration can support the creation of international data sharing practices for supporting decision making around novel technologies (see Box 3.1).

4) **Common accountability frameworks** at national or international levels can ensure AI tools and their underlying models meet rigorous ethical, environmental, and educational standards, and respond to the needs of all students. Education systems could require AI-enabled tools to receive certification before allowing them into classrooms. Responding to minimum quality assurance criteria, such as producing evidence of a positive impact on learning outcomes of students with SEN, can ensure their needs are prioritised over pure technological development and commercial interests.

   Turning again to the health field, the Coalition for Health AI (CHAI) created a "nutrition label" for AI tools to disclose important information to users, such as the intended use and known risks of the AI model (see Box 3.1). This approach could be adopted by the education field within and/or across countries to ensure the tools meet minimum requirements, such as 1) designed with students with SEN; 2) backed by research that shows it improves learning outcomes and is more effective than alternative tools; 3) is accompanied by teacher training; and 4) is ethical, sustainable and secure. This would also help make the selection, consent and use of tools more transparent for schools, educators and parents/guardians.

Effective and collaborative decision-making processes are needed to establish AI systems that support all students, especially those from disadvantaged and vulnerable populations (such as those with SEN). More importantly, understanding the role and limitations of AI, both currently and in the future, can allow education stakeholders to make informed, evidence-based decisions to mitigate inequity. Prioritising research and professional development, weighing the benefits and risks when making decisions, and consulting with the users themselves (students with SEN, teachers and other education practitioners) is vital to using AI in the classroom equitably and inclusively.

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Notes

[1] AI and its applications in education are evolving, given the fast-paced nature of technology development. This review therefore does not claim to be comprehensive and information about specific tools, while accurate at the time of publication, could be quickly outdated.

[2] Although a key consideration when designing, developing, and procuring tools that use AI to respond to the special education needs of students, intersectionality was not included as a selection criterion for this review due to a lack of evidence and the limited scope of this paper. Although not related to AI specifically, information on intersectionality between different dimensions of diversity can be found in (Varsik and Gorochovskij, 2023[139]).

[3] https://speechtools.co/daf-pro

[4] https://www.ablenetinc.com/soundingboard/

[5] https://www.smartyearsapps.com/

[6] https://emovocare.com/

[7] https://www.nuance.com/dragon/industry/education-solutions.html

[8] https://www.brainasoft.com/braina/#features

[9] https://www.tobiidynavox.com/

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[11] https://www.herts.ac.uk/research/impact-our-research/case-studies/robots-for-health-and-social-care

[12] https://luxai.com/robot-for-teaching-children-with-autism-at-home/

[13] https://corporate-internal-prod.aldebaran.com/en/world-autism-awareness-day-nao

[14] https://www.bbc.com/news/uk-england-somerset-57622059

[15] https://tihupe.ee/

[16] The OECD.AI Catalogue of Tools and Metrics for Trustworthy AI is a repository of tools and metrics which are designed to help AI actors develop and use trustworthy AI systems and applications that respect human rights and are fair, transparent, explainable, robust, secure and safe. The Catalogue of tools is a platform where AI practitioners from

all over the world can share and compare tools and build upon each other's efforts to create global best practices and speed up the process of implementing the OECD AI Principles.

[17] https://oecd.ai/en/