#EdTech Hub
Realising the potential of technology in education

Using education technology to support learners with special educational needs and disabilities in low- and middle-income countries

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United Nations Convention on the Right of Persons with Disabilities (CRPD), General Comment No. 4:
States parties must ensure that the rapid development of innovations and new technologies designed to enhance learning are accessible to all students, including those with disabilities.

UNESCO Salamanca Statement, viii, 1994:
Those with special educational needs must have access to regular schools, which should accommodate them within a child-centred pedagogy capable of meeting these needs.

1. Introduction

The use of education technology (EdTech) has grown substantially around the globe over the last several decades. Tech solutions have penetrated most facets of education service delivery and there is increasing agreement that technology can help make education more effective, efficient and equitable in countries all over the world.

One area where EdTech holds potential to enhance learning is amongst children with special educational needs and/or disabilities (SEND). While data on SEND is difficult to obtain, particularly in low- and middle-income countries (LMICs), UNESCO's Global Education Monitoring summary estimates that there are 93 million children under 14 with a moderate or severe disability (UNESCO 2014). Of these, approximately 75 million children live in low- and middle-income countries (LMICs), with a large portion located in sub-Saharan Africa. Using data from across 51 countries, UNESCO projects that primary completion rates are at least 10 percentage points lower for students with a disability.

Box 1. Education Outcomes for Learners with SEND

Children with disabilities are likely to have significantly lower access to education than children without disabilities. For example, in Malawi and Tanzania, children with disabilities are twice as likely to never have attended school than children without disabilities. In Burkina Faso, this increases to two and a half times, while in India almost three-quarters of children with severe impairments are out of school.

This lack of access negatively impacts learning outcomes. Literacy rates in Tanzania are 23 percentage points lower amongst people with a disability (GMR 2013/4). Similarly, in Uganda, literacy is 13 percentage points lower for students with physical/hearing impairments, and 22 percentage points lower for those with mental impairments.

Source: UNESCO GEM 2013/14 Summary

Box 2. Defining persons with disabilities and special educational needs

Throughout this document we use a number of key terms. These terms may sometimes be used differently in different countries and contexts. Please see Box 3 for additional definitions.

We adopt the definition used in the UN Convention on the Rights of Persons with Disabilities (UNCRPD) which states that 'Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.' The Convention clearly states that: 'disability is an evolving concept, and that disability results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders full and effective participation in society on an equal basis with others.' (UNCRPD)

The term 'special educational needs' has varying legal definitions across different countries (see European Agency for Development in Special Needs Education for examples). In general, a child or young person has special educational needs if s/he has a learning difficulty or disability that calls for special educational provisions. A child with SEN may have greater difficulty in learning than the majority of others of the same age, or have a disability hindering him/her from making use of educational facilities generally provided for others of the same age.

Throughout this brief, we have chosen to use the term 'special educational needs and disabilities' (SEND) as the most expansive term to discuss the needs of children who need extra provisions to access and participate in education and to learn.

These low completion rates reflect an inadequate focus on ensuring educational processes and practices are designed to meet the needs of SEND learners. Technology has the potential to play a significant role in helping to bridge this gap by facilitating access to education, increasing participation, and supporting achievement for children with disabilities. Technology can directly support children with SEND, and can also be used to support schools and teachers to be more inclusive of *all* learners. However, EdTech remains under-utilized as a tool to support SEND learners in LMICs, with limited evidence of impact of these tools to date.

Eager to address these challenges and realise the potential of EdTech, policymakers and education decision-makers understandably ask, "what technology should I use to support children with SEND, and what are the costs and availability of those options?" This brief posits that instead, they should be asking, "what are the needs of SEND learners, what needs to be done to address them, and what role might technology play?" More importantly than throwing technology at the problem, decision-makers must embrace a system-wide approach to developing inclusive education. While the 1994 Salamanca conference (UNESCO) on inclusive education argued that all children should be enrolled in regular schools unless there are compelling reasons to do otherwise, the reality is that many countries still have children with disabilities who remain out of education systems, or indeed, in many contexts, access schooling only through a segregated 'special' school system. With this in mind, the brief focuses on how policymakers can make decisions about EdTech to support SEND learners while offering them the rationale and tools to move towards an inclusive approach.

Section 2: Building inclusive education systems. The brief starts by introducing the concept of inclusive education and recommends that policymakers take system-wide actions to move toward inclusive education to support the needs of *all* learners.

Section 3: EdTech for SEND at the classroom and school level. The brief then focuses on how EdTech can be used to directly support teaching and learning for children with SEND. While EdTech has the potential to support SEND learners by strengthening education system functions such as data collection, management, administration, teacher training, and more, these uses are beyond the scope of this brief. In focusing on the school and classroom level, the brief introduces the Universal Design for Learning (UDL) framework and considers how accessible and assistive technology can support implementation of UDL principles in schools and classrooms. This section also examines the limited available evidence on specific uses of technology to support learning outcomes for children with SEND that decision-makers should consider.

Section 4: Three key steps for decision-makers.The brief concludes by proposing a set of three steps that policymakers and decision-makers should take before investing in any EdTech solutions to support children with SEND.

The brief also includes a table that offers description, costs, availability, and examples of accessible and assistive technologies to support children with SEND in low- and middle-income countries. It ends with a list of resources for further reading.

2. Building inclusive education systems

Whether using technology or not, policymakers should take an inclusive approach to improve education systems for *all* learners.

How should education policymakers support students with special educational needs and/or disabilities? While this is an exceptionally complex question that goes far beyond the scope of this brief, this section provides a brief overview of foundational areas that policy-makers should consider when strengthening SEND education. Importantly, by considering and incorporating these concepts into their education systems policy-makers can strengthen their systems for all learners, not just those with SEND.

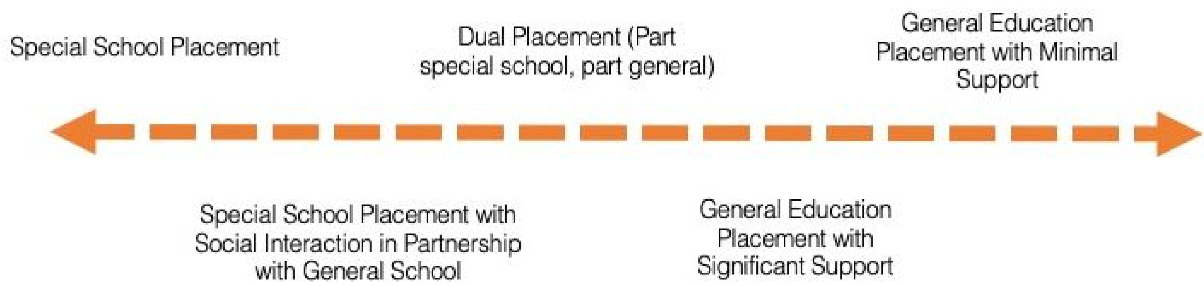
Since the Salamanca Declaration, policymakers around the world have begun moving towards **inclusive education** systems. While segregated approaches, in which SEND students are separated into special schools, are still prevalent in many countries (particularly in LMICs), education policymakers should be exploring and implementing measures to improve inclusion in the education system.

When moving towards inclusive education, policymakers must look beyond a "one size fits all" solution, and instead focus on creating a system that supports students to realise their full academic and life potential. This requires policymakers to focus on key principles including:

- Remembering that inclusion is a process, rather than a one-time event.
- Designing robust processes to identify and remove barriers for all students.
- Ensuring the presence, participation and achievement of all students.
- Placing an emphasis on those groups of learners who may be at risk of marginalization, exclusion or underachievement.

Appropriately supporting students may require education systems to offer a spectrum of provision to meet learner needs. This might range from inclusion in general education classrooms through to stand-alone facilities for those with difficulties severe enough to prevent their participation in general classrooms. Figure 1 highlights the spectrum of services policymakers may consider, while Box 3 provides more details on segregated, integrated and inclusive approaches to SEND education.

Figure 1. Spectrum of Service Provision for SEND Students



Box 3. Approaches to educating children with disabilities

Segregated Education: Children with disabilities are educated at special schools or at home. Special schools view the child, rather than the teacher or education system, as the problem, and define the child on the basis of his or her impairment and separate him or her on this basis (Stubbs 2008, 43). While special schools can cater to children with profound and complex difficulties, and centralise specialised equipment, resources, and specially trained teachers, segregation may not be necessary and children may be prone to continued social exclusion or discrimination. The costs of educating children in special schools may be higher than in mainstream schools, and children may face a longer distance to school (Mattingly & McInerney, 5).

Integrated Education: Children with disabilities attend special classes or units in mainstream schools. This often describes the process of bringing a child with SEND into a mainstream school, and differs from inclusive education in that it views the child as the one who must be 'ready' for mainstreaming in the system, rather than viewing the education system and/or the teacher as needing to be ready for the child.

Under an integrated approach, resources are often focused on an individual child, instead of on preparing a teacher or classroom to offer more inclusive education (Stubbs 2008, 44).

Inclusive Education: Children with disabilities learn effectively in mainstream schools where the whole system has been changed to meet all children's needs. An inclusive education system can be defined as "one that accommodates all students whatever their abilities or requirements, and at all levels – pre-school, primary, secondary, tertiary, vocational and life-long learning" (UNICEF). Inclusive education creates better schools, beginning with the concept that *everyone* is different, rather than just those with disabilities (Singal et al 2017, 9). At a policy level, it means prioritizing the goal of offering every individual a relevant education, with flexibility and child-centred pedagogy. Furthermore, research indicates that actively including children with disabilities in mainstream settings does not negatively impact children without disabilities (Singal et al 2017, 9).

For more information, see Inclusion International's Frequently Asked Questions.

Implementing an inclusive education approach requires substantial time and resource investments, but generates many rewards for all students. The shift towards inclusive education might involve adapting curricula, enhancing school infrastructure, training teachers, and supplying teaching aids and materials. However, adopting inclusive education approaches has important benefits for all students. For example, the **universal design for learning** (UDL) framework, which is outlined in detail in the next section, helps to bring more robust-child centred learning practices into classes, hence benefiting all students.

With the above in mind, when policymakers are exploring how technology can support SEND learners, they should first consider what they can do to improve the inclusion of their education systems, with or without technology. The potential of technology to support SEND learners is best maximised in the context of an inclusive education system, which should be the starting point for policymaker action.

3. EdTech for SEND at the school and classroom level

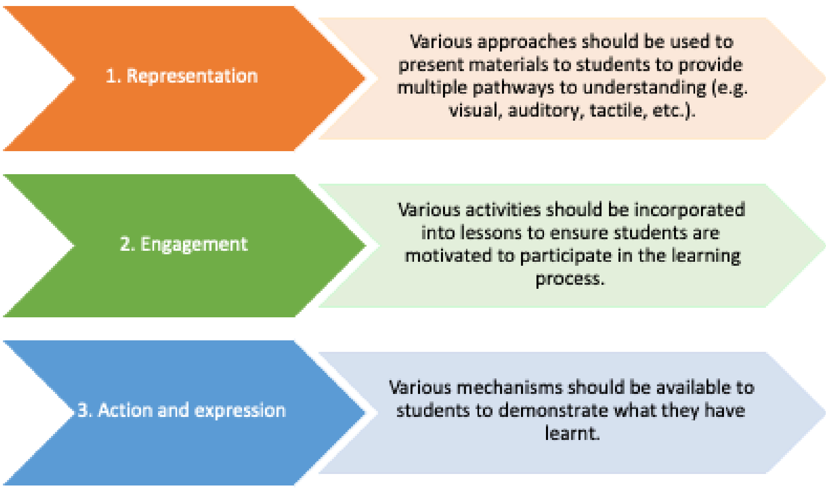
At the school and classroom level, policymakers should apply a Universal Design for Learning approach and a mix of accessible and assistive technologies to support SEND students.

Several school- and classroom-level frameworks provide powerful insights into how EdTech can be deployed to support SEND students (Banes et al. 2019). One of these is the Universal Design for Learning framework.

The UDL framework is designed "to improve and optimize teaching and learning for all people based on scientific insights into how humans learn." The framework gives SEND students access to a wider curriculum, reduces stigma and increases social inclusion, can change attitudes towards diversity, and results in higher achievement for children (Mattingly & McInerney, 6). The framework can be "used by educators, curriculum developers, researchers, parents, and anyone else who wants to implement the UDL framework in a learning environment" (CAST).

The framework aims to ensure that learning experiences are accessible to and motivating for all students, regardless of whether they have learning disabilities. It offers students flexibility in both the way they learn and how they can demonstrate the knowledge, skills or competencies that they have acquired. At the same time, it enhances the knowledge and ability of teachers to deliver child-centred learning experiences to all children. The approach comprises three key principles displayed in Figure 1.

Figure 1. Universal Design for Learning Framework



Although the implementation of UDL does not depend on access to technology, technology can help facilitate the application of the three UDL principles in schools and classrooms. Literacy research has found that when EdTech was integrated with UDL, it led to significant gains in vocabulary for students with and without disabilities, as well as bilingual students (Banes et al. 2019). With declining costs of producing digital teaching and learning materials and of mobile readers and tablets, which are more available than ever to school-age children, "in some countries and contexts, digital textbook provision may be a sound investment that may include video versions in sign language, simplified language, audio, DAISY and other formats accessible to a range of learners with and without disabilities" (Sæbønes et al. 2015, 11).

Decision-makers should consider using three types of technology in schools and classrooms to support the three principles of UDL:

1. **Majority Technologies:** These are general purpose tools that don't necessarily include features addressing a specific SEND. This may include projectors, computers, or generic software packages.

2. **Accessible Technologies:** These are products, equipment and systems that provide students with SEND access to mainstream services or content that might not be otherwise accessible to them. These may include built-in accessibility features, such as speech to text tools, that all students can use, but which can specifically address the learning needs of students with various disabilities (Banes et al. 2019, 11). Laptop and tablet technologies commonly available in LMICs often have built-in functions and features that increase access to learning and effective delivery of basic skills (Banes et al. 2019, 80 - 81). When considering accessible technology options for their contexts, LMIC policymakers should ensure that the technologies that they procure include at least some, if not all, of the following features:

   Table 1. Functions and features built into common LMIC tablet and laptop technologies that make them accessible and increase access to learning and effective delivery of basic skills

Category of special educational need or disability	Common features and functions across Windows, iOS, Android, and Chromebook systems
Physical	Voice or speech recognition; keyboard shortcuts; touchpad or keyboard / mouse adjustments
Vision	Braille displays; text to speech; on-screen magnification; high contrast settings; adjust colors and font size
Deaf and Hard of Hearing	Video creation software or applications; subtitles and captions for videos; audio volume or sound balance; on-screen notifications and alerts
Cognitive and Learning	Text prediction; voice or speech recognition; simple reading view

   Adapted from Banes et al. 2019, Annex A, p. 80.

3. **Assistive Technologies:** In an education context, assistive technologies are tools explicitly designed to enhance learning for persons with specific disabilities by allowing them to become mobile, communicate more effectively, see and hear better, or participate more fully in learning activities. They are often individualized and provide the means of access to participate in educational, social and recreational opportunities, and empower greater physical and mental function and improved self-confidence (Sæbønes et al. 2015, 12). They may include devices such as phonetic spelling software, text-to-voice applications, picture-based communication, talking calculators, braille note takers, and much more. Assistive technologies reduce, if not eliminate, barriers to help individuals with SEND participate in learning and related tasks, which otherwise might not have been possible (Ahmad 2015, 64).

> **Annex 1 of this brief** presents a table which highlights costs, availability, and the potential for impact of assistive technologies in LMICs. The table also includes specific examples of products and of how they have been used in similar contexts (Banes et al 2019, 88-100).

Access to accessible and assistive technology remains limited, as does evidence on the use of assistive technologies in LMICs (Borg et al 2009). Only five to 15 percent of children in LMICs who need assistive technology have access to it. Barriers include lack of awareness of benefits and accessibility functions available on majority technologies, limited awareness of assistive tech products and services, short supplies of accessible tech, inequities in access, poor supporting infrastructure, and high costs and financial obstacles (Singal et al 2017, 66; Sæbønes et al. 2015, 12).

Additionally, robust evidence on how to best provide a meaningful and effective educational experience for children with disabilities in formal school settings in LMICs, is limited (Singal et al 2018, 8). Where it exists, research finds that integrating both accessible and assistive technologies, and supporting these with robust pedagogical approaches, can increase communication and motivation, and improve learning outcomes, for SEND students (Banes et al 2019, 19).

Ministries of Education have an important role in providing appropriate resources to schools and students. Although in the Africa region the majority of assistive technology products are provided by the private and NGO sectors, rather than by government, many LMIC ministries of education do procure or provide majority and accessible technologies for use in schools, along with teaching and learning materials (World Health Organisation 2019, 4). Ministries may also play a role in regulating or subsidizing assistive technologies. Ministries thus have an important responsibility to ensure that the technologies they procure and provide have the necessary features to make education more accessible, participatory, and fruitful for *all* children, especially SEND learners.

Evidence summarized by Banes and coauthors provides insights for policy-makers in LMICs to consider as they explore the potential of EdTech to support SEND learners (Banes et al 2019, 20-21). Insights include:

- A review of assistive technologies found that the most effective ones for students with learning disabilities include **word processing, multimedia and hyper-text. Speech to text** has also generated positive, albeit smaller, effects.
- **Subtitles, text highlighting, and tablet-based sequential text tools with touch capacities** have generated significant academic gains amongst hearing impaired students.
- **Interactive story-books** have been shown to help develop language skills amongst hearing-impaired preschoolers.
- EdTech tools that provide **flexible approaches** to targeting learner strengths have been shown to increase learning amongst intellectually disabled students.
- **E-books with multimedia functionality** have been shown to be helpful to support learning amongst students with ADHD.

- Children with hearing impairments can benefit from **multimedia dictionaries** that show the print and signed versions of a word, complemented by an image.

Using the UDL framework to highlight technology types, Table 2 illustrates how technologies could be used by teachers and learners to support in-classroom learning in various ways.

Table 2. Types of Technology by UDL Principle

UDL Principle	***Technology Options***
Representation	• *Computer-based games and puzzles* can expose students to words and numbers in new ways. • *Electronic hand-held magnifiers* can increase ease of reading for vision impaired students. • *Multimedia content* provides multiple representations of concepts to children. Building in these multiple representations increases the likelihood that students with varying special needs can engage with a concept. • *Portable learning:* Technology can make learning accessible from anywhere. Well-designed learning management systems can allow students to access tools and content beyond the classroom. • *Radios and audio recorders* can deliver information through different mediums including music, spoken word, etc. • *Screen readers* translate written text on computers to spoken word to support visually-impaired students. • *Tablet-based* tools can be used to easily access materials and mediums either online or stored on the device. Displays can be modified to support access by vision-impaired students. • *The internet* can be used to execute research and obtain perspectives that may not be available in print. • *Videos* can demonstrate difficult concepts in a variety of ways that may not be possible in classrooms. • *Video-conferencing and online chat* can help students experience different ways of socialising and communicating, as well as new words and concepts. • *Virtual/Augmented reality tools* can support virtual field trips to museums, other countries or ancient sites.
Engagement	• *Braille notetakers* allow vision-impaired students to both read and comprehend text, as well as take notes and write documents. • *Braille keyboards and refreshable braille displays* allow students with visual impairments to engage with written language. • *DAISY talking books* can synchronize text with speech so that students can engage with both visual and aural content at the same time • *Interactive storybooks,* which can be delivered on tablets or phones, can help develop early grade literacy and numeracy skills. Touch-enabled

	interactions generate audio and/or visual descriptions of the content in the story. Integrating interactive games can expose students to mathematical or other types of concepts. Interactive tools can be particularly beneficial for students with attention deficit disorder. • *Mind maps* can be used to highlight how interrelated concepts are connected. This is particularly helpful for students with Dyslexia. • *Smart speakers and voice interaction* can allow students to interact with and apply concepts that they may.
Action and Expression	• *Augmentative and Alternative Communication (AAC) devices* can support students who struggle to communicate in traditional ways to share their learnings in non-traditional ways. • *Alternative keyboards* can allow students with various SENDs (e.g. motor disabilities, visual impairments, etc.) express information. • *Computer-based adaptive testing tools* can allow students with SEND to complete assignments. • *Online chat tools* allow students to participate more actively in group communication sessions. • *Speech to text platforms* provide real-time transcription of speech to text on screens, supporting students with various SEND to communicate information that they have learned.

4. Three key steps for decision-makers

In deciding which EdTech tools to deploy in schools, policymakers and programme designers should: (1) identify children with SEND, and consult with them and their communities to understand needs; (2) think about how potential tech options can integrate across all features of the education system; and (3) determine the appropriateness of technology options based on children's needs, system capacity, and value for money. These steps are elaborated below:

Identify children with special needs, and obtain and analyze data to determine their specific needs, skills, and capacities, and how technology might support them.

- **Identify children with special needs**. Given the large numbers of children with disabilities who are out of school, and many children who have not had their special educational needs or disabilities identified, policymakers should consider using multiple means to identify children with SEND, including those who may not have a formal diagnosis or may not be in school. Data on special needs as well as learning outcomes should be gathered and considered. Where special schools still exist, the needs of children in *both* special schools and mainstream schools must be captured.

- **Consider all functional domains, as outlined by the Washington Group on Disability Statistics, for ages five to seventeen** when gathering data on children's special educational needs or disabilities: seeing, hearing, walking, self care, learning, remembering, controlling behavior, focusing, routine (accepting change), friends, worry, sad, understanding (within and outside the household) (Singal et al 2017, 19).
- **Calibrate your understanding of the needs of children identified as having SEND by involving and consulting** with students with disabilities, their parents, and community members, as well as Disabled People's Organisations (DPOs) or other relevant NGOs or CSOs. This will help ensure that tools are designed, developed, or implemented in a way that aligns with individuals' needs, and may also result in people with SEND feeling more empowered and engaged with the tools ultimately chosen. Finally, people with SEND can also make important contributions in helping to overcome negative societal norms surrounding people with disabilities.
- **Use specific information about individual needs to determine assistive technology requirements**, taking into consideration availability, accessibility, affordability, adaptability, acceptability and quality (Singal et al 2017, 66).
    - **Accessibility, adaptability, and quality:** Assistive technology should be compatible with users' needs, ways of life, and local customs; unobtrusive by local standards, and physically comfortable and safe for users. It needs to be durable, dependable, and reliable, especially in remote areas and rugged conditions. Devices should be portable and easily understandable and operable (Ahmad 2015, 66).
    - **Availability and affordability:** Government can provide support in the provision and purchase of assistive technology devices, free of charge or at subsidized rates. The devices should ideally be easy and affordable to assemble and maintain, so that they can be kept in working order and repaired using what is available locally (Ahmad 2015, 66).
- **Identify how students can make the most effective use of their access to technology both within and beyond the classroom.** This means that when thinking about integrating EdTech, policymakers must consider how children will be trained to use the tools, whether they will be able to take these outside the classroom to support home-based learning, and how the students can integrate these tools into their life outside the classroom to increase their independence and personal agency. This aligns with the 'Access to learning' and 'Learning to access' model commonly used in SEND approaches (see for example, the Welsh Government's Support for children and young people with vision impairment in educational settings, 2019).

Take stock of existing education system implementation capacity and assets, including policy frameworks, physical and digital infrastructure for both SEND and technology, and teachers' and SEND specialists' skills and abilities. Ensure solutions are designed to align with existing capacity.

- EdTech can be an important tool to enhance education, but it is no substitute for robust teaching. High quality teachers are core to student success. Technology should be adapted so as to augment high-quality pedagogical approaches. Take stock of current pre-service and in-service teacher training. Are all teachers supported to meet the needs of students with SEND? How can teacher professional development be strengthened to support this?
- Teachers require training to be able to realise the benefits of any EdTech tool.Teachers should be trained on both supporting children with SEND, but also on integrating accessibility and assistive technology to support learning. Without training, ineffective tools might be selected, or good tools may not be appropriately deployed. Either of these scenarios can result in significant expenditures realising little impact or value for money.
- Where Individualized Education Plans (IEP)[1] are in use, integrate EdTech tools into them to ensure tech is used in the most effective manner to complement other learning experiences. Referring to the EdTech tools, and describing the way in which these are individualized for the student, can help provide a more comprehensive overview of the support being provided.
- Ensure ongoing support is in place as it is critical to the success of EdTech tools. While procuring and adopting EdTech tools is a significant undertaking, ongoing support is required to ensure the investment achieves value for money. Support may be in the form of maintenance and IT technicians who can fix devices if they malfunction, insurance for device breakages, ongoing teacher training, and technical help-desks.

Examine available and locally developed technological tools, including accessible and assistive technology, that are available, affordable, and sustainable. Taking student needs and implementation capacity into consideration, identify a mix of tools to support student learning.

- The table in Annex 1 of this brief can be used as a starting point for education policymakers in LMICs to identify possible technology solutions.
- **Sometimes low-tech can be just as effective as high-tech.** Technology can be used to improve the lives of persons with disabilities in many ways. However, at times, technologies that are often the most effective can be low tech and not always of higher cost. Depending on the need, basic assistive devices such as eyeglasses and hearing aids can be just as effective as more expensive devices such as braille note takers or tablets equipped with accessibility functionality. However, it is important to note that in some countries even the most basic of assistive technologies, for example wheelchairs and eyeglasses, are not easily accessible by the general population (World Health Organization 2019).

[1] An IEP is a tool designed to help teachers and other stakeholders plan for, teach, and review progress of SEND students. The IEP normally includes, amongst others, personal, medical and education data about students, insights into capacity, short- and medium-term goals, a description of techniques and strategies to achieve the goals, and a description of additional services required.

- **Consider how any new technology will be integrated** into existing education policies, curricula, strategies and tools.
- **Undertake a value-for-money assessment** of all elements associated with deployment before deciding whether to purchase EdTech. Purchasing and deploying an EdTech solution is expensive. Not only do devices and software cost significant amounts, but this is compounded by recurrent costs such as servicing and teacher training. Low- and middle-income countries face limits in terms of available funding, foundational infrastructure, teacher capacity, and the ability to provide ongoing support services. All of these factors must be considered when assessing the potential costs and benefits of deploying EdTech tools. That said, **an incorrectly narrow conception of value for money** as "the impact that reaches the most people for the lowest cost" **has a negative impact on the most marginalized, often people with disabilities**. Those with the most complex needs and intersecting inequalities are most likely to be at risk of exclusion as they are more challenging or expensive to reach. Thus, reaching only the easiest to reach at low cost is not inclusive or effective; VfM must instead focus on the optimal use of resources to achieve the intended outcome, which in this case, is to deliver quality education for *all* children (Singal et al 2017, 8).

Annex 1: Description, costs, availability, and examples of accessible and assistive technologies to support children with SEND in low- and middle-income countries

This table is adapted from Banes et al 2019, pp. 88 - 100. Technology types included on the World Health Organisation's Priority Assistive Products List are marked with an asterisk.

Technology	Details
Hand-held magnifier devices and apps*	**Supported needs and disabilities:** blind; low vision **Description:** Magnifies text from a printed page; can also change colors and contrasts to support learners with low vision. **Costs in LMICs:** Typically sell for$495 per unit. New models from ION for $99. Low-tech solutions/lens available from $50-$150, depending on style and features. **Availability and barriers to access and use in LMICs:** Typically out of reach due to cost. Apps on smartphones may offer an alternative. **Products and examples of use in LMICs:** WeZoom magnifier, Magnifier 4 Reader and Visor are three apps containing a magnifying glass and high-contrast image filters to assist visually impaired students.
Braille devices*	**Supported needs and disabilities:** blind; low vision **Description:** Used to both read and comprehend text and braille-ready files through a refreshable braille display bit. Notetakers are also used to record notes and documents using a chording keyboard. Has the potential to support literacy from early grade through employment. **Costs in LMICs:** Traditional models cost around $5000 – the Orbit has been made available for around $500. The Jot-A-Dot model costs around $425. Pricing information was not available for Dot Mini, but the Dot Watch costs around $300. **Availability and barriers to access and use in LMICs:** Traditional model costs are prohibitive. New models have significantly lower costs, but $300 - $500 is still expensive for use in LMICs. Also needs investigation of potential use in a range of languages. **Products and examples of use in LMICs:** The Orbit Reader 20 is a braille display, book reader and note taker. It can be used as a standalone device that reads directly from SD cards, or can be connected to a computer or mobile phone. The device is language agnostic. Jot-A-Dot is a pocket-size mechanical brailler weighing less than 500 grams. It uses direct six key Braille entry for fast and accurate Braille. A School to School International evaluation found that primary students in Lesotho who are blind or have low vision felt more engaged and thought Jot-a-Dots improved their reading. The Dot Mini is a smart braille reader that also integrates audio technology. The device can provide access to books, magazines and even movies. The same company also manufactures the Dot Watch, which is a smart watch equipped with Braille functionality.
Augmentative and Alternative	**Supported needs and disabilities:** Limited speech

Communication solutions*	**Description:** AACs establish a basis of communication using text and symbols to construct sentences for functional communications. They introduce the fundamentals of syntactic and semantic structure to support the evolution of literacy skills. AAC develops functional communication, an essential prerequisite for literacy from the early years through to adulthood for learners with limited speech. **Costs in LMICs:** Commercial software available in some languages for $50 - $200; open source solutions freely available as apps or for iOS and Android. Support and training require additional fees. **Availability and barriers to access and use in LMICs:** Low cost apps have been developed for iOS, but limited Android options. Greater awareness, distribution, and investments to increase functionality and tailor products to local markets are needed in LMICs. **Products and examples of use in LMICs:** Jellow is an AAC developed in India that received support from the UNICEF innovation fund. The application has over 1,200 icons and 10,000 pre-made sentences. LetMeTalk is a free tablet/phone-based app that supports communication through more than 9,000 simple images to support communication in all facets of life. JabTalk is another free app that combines personalized voice and images with a simple interface. Livox is a tablet-based alternative communication platform that can be tailored to meet the needs of the user in ways (e.g. hand control or eye control; condensed of simple layout, etc.).
Reading and literacy resources*	**Supported needs and disabilities:** Blind; low vision; deaf; hearing impaired; print disabilities, including cerebral palsy and dyslexia **Description:** Daisy (the **D**igital **A**ccessible **I**nformation **SY**stem) is a system to create digital talking books for people who have disabilities that impede them from reading printed materials. Software and hardware devices can interpret Daisy format files into text and voice output. Reading and literacy-focused applications incorporate various features designed to support learners with disabilities to build foundational literacy skills. For example, some readers integrate and synchronize text to speech output to allow learners with visual or other print impairments to match text to speech. These devices have the potential to support readers including not only early grades but also those later in life with delayed literacy development. **Costs in LMICs:** Dedicated hardware devices sell in LMICs for around $400. Smartphone and tablet apps are freely available. **Availability and barriers to access and use in LMICs:** Smartphone apps available freely, but implementation limited by content and product support for local languages. Operability on Android devices, and Daisy creation tools in local languages need further development. **Products and examples of use in LMICs:** Daisy Book Reader and Kota Daisy Reader are two android platforms that can be used to access these books. These books can synchronize text with speech Robobraille.org is an online platform that allows users to convert written documents to a variety of formats including mp3, braille and Daisy format. Bookshare is the world's largest online library of accessible ebooks (more than 800,000 titles) for people with print disabilities. It provides titles in audio, audio and highlighted text, braille, large font, and other formats to support learners with disabilities including dyslexia, blindness, cerebral palsy, and other reading barriers.

	AkooBooks, which started as a mechanism to distribute books to the blind and visually impaired, is Ghana's first publisher and distributor of audio books. The eKitabu Kenyan Sign Language Studio creates video storybooks presented using sign language.
Real time text communication*	**Supported needs and disabilities:** Deaf; hard of hearing; limited speech **Description:** Text based support to learners who are deaf or hard of hearing can support communication by sharing real time text between two or more people in a conversation. This has the potential to support people who are deaf and hard of hearing and people with limited speech, as a complement to Sign Language, and supports the development of functional literacy. Evidence that suggests that the use of text to enhance functional communication helps to practice and strengthen literacy skills. **Costs in LMICs:** The costs of dedicated devices are significant, and devices are not easy to localize. Some apps for phones and tablets have been developed for real time text using integrated keyboard, word prediction, and TTS for hearing communication partners. **Availability and barriers to access and use in LMICs:** The most widely used real time text solution for people who are deaf or hard of hearing is the dedicated device the UbiDuo, which is not widely available in LMICs. **Products and examples of use in LMICs:** DHChat supports face to face communication between deaf and hearing people without the need for sign language. Using a pair of devices linked via bluetooth, a non-deaf person can speak into the app and this gets sent to the deaf person on their phone as text. OviiChat and AVA are real-time text communicators for deaf people. Users type text into their devices, and all connected users receive updates in real time. My-own-voice is a voice banking app that supports individuals with speech or language disorders such as motor neurone disease or aphasia to create their own synthetic voice. Once users have recorded their voice they can upload it to their assistive device to communicate in their own voice.
Screen readers*	**Supported needs and disabilities:** Blind; low vision; print disabilities including vision and cognitive needs (dyslexia) **Description:** Essential for people who are blind or low vision, allowing them to access screen-based text and labels and convert them to speech output. May also provide braille output to a refreshable braille display. **Costs in LMICs:** Screen readers are available for free and at a range of prices, but LMICs often lack the support infrastructure (technical support, advice, training) for lower cost solutions. **Availability and barriers to access and use in LMICs:** Mobile and portable devices usually have a functional screen reader integrated into the OS, but may vary in quality depending on language. Some interfaces are not simple enough to benefit early grade readers. Limited localized voices may contribute to reduced uptake. **Products and examples of use in LMICs:** Non-Visual Desktop Access (NVDA) is a free screen reader that provides people with visual impairments access to Windows computers. The system works in more than 55 languages and has been used in more than 175 countries. JAWS screen reader provides both speech and braille outputs. The technology can help users navigate the Internet, write a document, read an email and create presentations.

Simplified mobile phone interfaces in local languages*	**Supported needs and disabilities:** Physical, vision, or cognitive disabilities; early grade readers without a disability. **Description:** Main means of electronic communication for many in LMICs. Simpler interfaces increase ease of access to core functionality for those with physical, vision and cognitive needs. Would also benefit any user accessing digital content, including early grade readers with or without a disability. **Costs in LMICs:** Free / low-cost. Has potential to expand usage of mainstream low-cost technologies and reduce the distraction factors inherent in platforms with open access to any app. **Availability and barriers to access and use in LMICs:** Need open interfaces based upon culturally relevant icons and local language. Many LMICs have not seen this as a priority for development historically. **Products and examples of use in LMICs:** Project Ray aims to deliver the benefits of smartphones to visually impaired people. The project combines simple gestures, tactile touching, voice recognition, and audio feedback to replace the traditional visual dependent smartphone platforms. Big Launcher is a mobile phone platform that aims to make smartphones accessible to those with visual impairments. Using large, user friendly, and customizable icons, the interface can be adapted for use by a wide range of users.
Accessible content creation tools	**Supported needs and disabilities:** Learning disabilities; low vision; physical disabilities **Description:** Accessible content is essential for supporting literacy among children with SEND. Tools either ensure that written documents are compatible with accessibility standards, or convert documents into a range of formats to support a diversity of needs. Potential for significant impact on the availability of early grade reading materials accessible to those with learning disabilities, limited vision, and physical needs. **Costs in LMICs:** Tools for checking and addressing accessibility issues have only been recently introduced to OS or productivity applications. Some third party and open solutions are available but are of mixed quality and cost. **Availability and barriers to access and use in LMICs:** Use is limited by the need to own current versions of apps and limited support for local languages. More plugins for familiar legacy systems to test accessibility issues and transform into alternative formats are needed to increase ease of use. **Products and examples of use in LMICs:** The Office 365 suite now includes an accessibility checker which allows you to review documents and emails to see whether they may cause challenges for people with disabilities. Similarly, Google has developed a variety of products to ensure internet access and content creation is more accessible for users with disabilities. Easy Converter Express HandTalk's website and pocket translators have been used in Brazil to translate Portuguese content into Brazilian Sign Language. The Clicker 6 literacy software has been used in South African schools to teach and learn South African Sign Language, and also supports students with dyslexia, learning difficulties, physical disabilities. www.psl.org.pk integrates video to support text, provides deaf children across Pakistan access to digital learning resources in Pakistan Sign Language (PSL).
Technology	**Supported needs and disabilities:** Learning and print disabilities; general literacy development

that simplifies and enhances text/content	**Description:** Tools provide visual cues to aid literacy and understanding of text among literacy learners. May include integrated thesaurus, dictionary, symbols and tools that review and recommend appropriate grammar, and tools that support simplification of written content via summaries of key points of complex text. Can enhance motivation and increase the underlying capacity to support early grade reading, regardless of age. Lifelong applications for those with learning disabilities or other forms of print disabilities. **Costs in LMICs:** Some tools are integrated into current versions of productivity solutions but do not support a diversity of language and are not usable by those developing literacy skills. The interface and advice are often complex for learners with emerging literacy. Some low-cost and free apps are available. **Availability and barriers to access and use in LMICs:** Cost, availability, and appropriateness for language and culture are barriers to use in LMICs. **Products and examples of use in LMICs:** Grammarly is a digital writing assistant that helps users ensure that their written language is simple, correct, and to the point. Global Symbols is a free AAC platform that allows users to either create new or access existing symbols to provide alternative communication approaches for students with low levels of literacy or learning disabilities. Strategic Reader helps students learn to learn to study more effectively. The program embeds multimedia and interactive exercises into reading tasks to help students improve their focus, reading comprehension, memory, and confidence. Tactopus is an early grade literacy solution that combines tactile graphics with an interactive audio tool delivered through a smartphone app. Enuma develops a range of accessible games and applications to support children with disabilities to learn independently. This includes the KitKit School, which presents information in a highly engaging, easily accessible, way.
First language text to speech (TTS)	**Supported needs and disabilities:** Blind; low vision; dyslexia; cognitive impairment; also supports literacy development **Description:** Essential building block of assistive solutions used by people with disabilities. TTS interprets text displayed on a screen into speech to support a variety of needs, including literacy, for those that have little or no vision, dyslexia or other cognitive impairment. Access to high quality TTS is an essential component of natural interfaces for many with limited literacy. Whilst such TTS would support those developing literacy skills, the impact of such technologies increases digital access for significant parts of the population. **Costs in LMICs:** Costs are variable, but costs of licenced, high-quality voice have a severe impact on the quality of entry level AT. **Availability and barriers to access and use in LMICs:** A lack of open tools to create new voices limits creation. A pipeline for production of voices that streamlines the process could assist in many locales. Further global mapping of TTS, costs, and quality is needed. **Products and examples of use in LMICs:** Bloom, Storyweaver, and World Around You offer mother tongue books with text-to-speech accessibility.
Speech recognition tools	**Supported needs and disabilities:** Learning disabilities; physical disabilities; dyslexia; low literacy populations **Description:** Converts speech to text, creating sentences as spoken. Extremely valuable in supporting the creation of written text, and functional literacy, for those with learning disabilities, physical needs and other conditions such as dyslexia. Potential for impact on low literacy populations.

	Costs in LMICs: Not widely available in languages local to LMICs, but some open resources are under development. **Availability and barriers to access and use in LMICs:** Not available in many languages common in LMICs. Further research on how to increase the availability of voice-driven interfaces would be beneficial and would support functional literacy for those facing significant barriers. **Products and examples of use in LMICs:** Project DeepSpeech aims to develop an automatic speech recognition (ASR) engine to make speech recognition technology openly available. Kaldi is an open-source speech recognition toolkit that aims to have have modern and flexible code, written in C++, that is easy to modify and extend. Important Julius, which is mainly used on linux, is a vocabulary continuous speech recognition (LVCSR) decoder software for speech-related researchers and developers.
Alternative keyboards and calculators	**Supported needs and disabilities:** Physical disabilities; low vision. **Description:** Widely used to support literacy and numeracy in the early years, these are keyboards and calculators with large keys, alternative layouts, colour coded keys and high visibility. Important tool for the creation and interaction with text and numbers. The limitations of standard keyboards and calculators reduce ease of access for many with limited movements or low vision. **Costs in LMICs:** Generally costly. Most existing alternative keyboards use keytops suited to US or UK English only. Creating print runs of keyboards for specific languages is expensive. **Availability and barriers to access and use in LMICs:** 3D printing and keyboard stickers offer possible solutions to adapt designs with appropriate text for use in a range of languages. **Products and examples of use in LMICs:** AT Makers connect participants in the Open-Source Hardware and Software communities to help them to create hardware solutions equipped with the software to help people with severe physical and cognitive challenges. Talking Calculator apps can speak names, numbers, and answers aloud and lets users record their own voice.

Further reading

This brief drew heavily on URC's 2019 report, Using Information Communications Technologies (ICT) to Implement Universal Design for Learning (UDL), which is our first suggestion for further reading. Additional resources include (1) tools for designing and improving education systems to become more inclusive and (2) resources for supporting learners with SEND using EdTech.

A full list of both resources for further reading, as well as references for this brief, is available in the EdTech Hub Evidence library **here**.

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