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ORIGINAL RESEARCH

Formative Evaluation of an Interactive Personalised Learning Technology to Inform Equitable Access and Inclusive Education for Children with Special Educational Needs and Disabilities

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Abstract
In accordance with the 2030 Sustainable Development Goal for Education, to promote equitable access and inclusive education for all, it is critical to explore if educational technologies can be used effectively by children with Special Educational Needs and Disabilities (SEND). It has been argued that educational technologies need to be tailored to the individual needs of children with SEND, otherwise they can create new layers of exclusion at school. The aim of this study was to examine the suitability of an interactive, personalised, educational technology, designed to support the learning of foundational skills, that is being introduced in several countries worldwide, for use by children with SEND. A participatory formative evaluation was conducted with ten academic experts in SEND. Each expert interacted with the technology individually, then gave written feedback through a semi-structured review form, before engaging with the other experts in an online group discussion. Qualitative data were analysed by reflexive thematic analysis. Six themes emerged pertaining to the strengths of the educational technology and areas of weakness where improvements are needed to support children with vision impairment, hearing, and functional difficulties through recommended hardware, and software updates, and by considering how the technology could be used to boost children's motivation, and the role of the teacher in supporting children with SEND to use the technology effectively. Implications for instructional design decisions, based on research evidence, are considered for promoting equitable access and inclusive education for children with SEND through technology-supported personalised learning platforms.

Keywords Educational technologies (EdTech) · Special educational needs and disabilities (SEND) · Equitable access · Inclusive education · Instructional design · Technology-supported personalised learning

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1 Introduction

Stimulated by the 2030 Sustainable Development Goal for Education (SDG4) which aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", increased attention has been paid to foster equity and inclusion in educational settings. It has been argued that concepts such as equity and inclusion should be viewed as principles that inform all aspects of educational policy (see Ainscow, 2020). From an international perspective, inclusion in education is "increasingly seen more broadly as a reform that responds to diversity amongst all learners" (Ainscow & Messiou, 2017, p. 2). Even though many countries worldwide have started working towards the SDG4, it has been argued that learners with disabilities are a significant group that can still be marginalised from inclusive and equitable quality education (McLinden et al., 2023), particularly in low-and-middle income countries (LMICs) where the progress achieved has been considered insufficient to meet the SDG4 (Hennessy et al., 2021). For instance, despite improvements in equity and inclusion worldwide, disparities in access to education can still be captured for children with disabilities in LMICs, such as Kenya (Otieno et al., 2023).

The quest for promoting inclusive and equitable quality education for all has been translated in research attempts to devise teaching and learning strategies to accommodate learners with diverse needs. One tool that showed evidence of potential effect when used in education is technology. In recent years, technological developments have led to transformations in the field of education (Ratheeswari, 2018). The use of technology has enhanced current educational practices (Chauhan, 2017), as different technological tools demonstrated effectiveness in improving academic performance and skills of learners (Durgungoz & Durgungoz, 2021). To date, several studies have investigated the use of technology in education and its impacts on the typically developing students (Valverde-Berrocoso et al., 2022; Teng & Wang, 2021; Chauhan, 2017). However, research evidence shows that educational technology (EdTech) offers opportunities for personalised learning, by providing content and features that are adaptive to individual learners' needs (Outhwaite & Van Herwegen, 2023), and has potential to promote participation of all learners when it is "designed and implemented in an ethical, inclusive, and equitable manner" (Duraiappah et al., 2022, in Outhwaite & Van Herwegen, 2023, p. 4). While inclusive education seeks to mitigate exclusion practices in educational settings through designing different strategies (see Slee et al., 2019), if not tailored to the individual needs of children with special educational needs (SEND) (Yngve et al., 2021), technology can create new layers of exclusion at school (see Peruzzo & Allan, 2022). Yet, to date, limited attention has been given to evaluating the suitability of different technological tools for children with SEND, so it is not clear if or how the needs of children with SEND have been met in the design of different EdTech tools. In addition, there remains a paucity of evidence on how EdTech may promote equitable access and inclusive education for children with different functional difficulties, either through adaptations to the technology itself, or through changes to its implementation. This paper addresses these gaps in knowledge by focusing on the suitability of an interactive, personalised, EdTech for use by children with SEND.

1.1 Educational Technology for Children with SEND

Although SEND is a complex term to define, it usually refers to individuals with learning, physical, developmental, communication, behavioural, and emotional disorders, and learning deficiencies (see Bryant et al., 2019). These are individuals "for whom special provision needs to be made in order for them to learn and develop" (Goepel et al., 2015, p.65). While some of these individuals have visible differences (such as physical difficulties) and are often referred to as individuals with 'visible' disabilities, others with less visible differences (such as autistic spectrum condition) are often described as individuals with 'invisible' or 'hidden' disabilities (see Radulski, 2022). Whilst most research is focused on disability overall or on specific difficulties, rather than on what could be classified as 'invisible' difficulties (Kelly & Mutebi, 2023), the term SEND in this study is used to refer to individuals with visible and/or invisible difficulties. Previous research has associated SEND with poor social, emotional, and academic functioning (Avramidis et al., 2018; Heiman & Olenik-Shemesh, 2020; Cara, 2013). Children with SEND have lower peer acceptance, less friendships, and less interactions than their peers (Schwab et al., 2021), making it difficult for them to participate in social and academic activities. Children with SEND may also lack social-emotional and behavioural competences compared to their peers (Goh et al., 2021; Martin et al., 2017). There is a growing body of literature that recognises the importance of social emotional learning in achieving positive development outcomes (Oberle & Schonert-Reichl, 2017). As a result, there have been targeted efforts to increase the inclusion of children with SEND within mainstream education that have focused on different educational, social-emotional, psychological, and behavioural interventions that can be implemented at school (see Carroll et al., 2017). A study conducted by Hassani and Schwab (2021) indicates that most of the reviewed interventions in the field suggest some positive, but small effect, of social-emotional learning interventions for children with SEND. Given the recent increase with integrating technology in education, it is critical to examine how EdTech can promote equitable access and inclusion of children with SEND within mainstream schools. Further, it is important to determine if and how EdTech might support the social-emotional learning of children with SEND.

Educational technology is considered fundamental in "enabling learners with disabilities to access learning at school and reduce educational and social exclusion" (Lynch et al., 2022, p. 2), yet few studies have focused directly on this. One study by Rizk and Hillier (2022) investigated the role that digital technology can play in facilitating the engagement of students with SEND in Canada. Results suggested that digital technologies can boost the engagement of students with SEND, but this study did not explore if the use of technology also promoted learning gains for children with SEND. A further study, however, found that tablet devices may be used to improve the communication skills of children with Autism Spectrum Disorder (ASD) (Cabielles-Hernandez et al., 2017), and other research has shown that children with a range of functional difficulties in Malawi could use tablets and interactive applications (henceforth apps) to make progress in basic mathematical skills, although their rate of learning with this technology was slower than mainstream peers (Pitchford e al., 2018). Some other studies have investigated the use of technology amongst children with a range of disabilities, including Down Syndrome (DS) (Alfaraj & Kuyini, 2014; Gulliford et al., 2021), cerebral palsy (Karlsson et al., 2017), vision impairment (VI) (Thieme et al., 2017), and Attention Deficit Hyperactivity Disorder (ADHD) (Bakola et al., 2019; Guan-

Lim et al., 2020; Liontou, 2019). In general, these studies showed that considered design and implementation of educational technologies is needed to provide equitable access for children with SEND.

Although limited, whilst some previous research has explored the use of technology with children with SEND, there remains a paucity of studies investigating the impact of technology on promoting equitable access and inclusion of children with SEND within mainstream education. Consequently, there has been a call for research to evaluate the use of educational technologies with children with functional difficulties (Outhwaite et al., 2023b), and in different contexts, as only 5–15% of children can access assistive technology in low-and-middle-income countries (LMICs; UNICEF, 2016). Given that well-designed technology can have a significant impact on children with SEND and their education (Benton & Johnson, 2015), it is becoming increasingly important to take their needs into consideration when designing and evaluating educational technologies. A systematic review of the literature on educational technology for learners with disabilities in LMICs by Lynch et al. (2022) found that many studies were characterised by "little involvement of the beneficiaries and teachers in the research design" (p. 17). It is therefore necessary to understand which technological features benefit and hinder children with SEND from accessing and engaging with educational technologies effectively.

1.2 EdTech Under Investigation: Onetab and Onecourse

Tablet technology and interactive apps have received particular interest in the education of young learners, as touch screen tablets are lightweight and eliminate the need for other devices (such as a mouse) that rely on developed motor skills (Kucirkova, 2014). Furthermore, tablets afford opportunities for learning in different settings, including the home, community, and school environment, and have the potential to enhance children's engagement and learning (Svela et al., 2019). As such, interactive apps delivered on hand-held tablets are particularly suited for supporting the acquisition of core foundational skills that are typically learnt over the first few years of formal schooling (Pitchford, 2023a). A systematic review of literature by Outhwaite et al. (2023b) demonstrated that studies which used interactive apps to support the acquisition of basic mathematical skills predominately reported greater learning outcomes for young children than controls who received standard educational instruction. Furthermore, as some of these apps can support interaction of several children simultaneously, these apps have the potential to boost children's collaborative work and social-emotional skills as well as their mathematical understanding (Ingram et al., 2016).

The tablet technology evaluated in this study was designed and developed by the non-profit onebillion, which delivers personalised reading, writing and numeracy instruction in over 4000 learning units to individual learners via the onecourse app delivered on a onetab device (see Fig. 1). The software features a virtual teacher who describes 'how to' by demonstrating tasks, then the child is required to interact with the software to practice the task, during which they receive feedback on their interactions before they are tested on the skill being learnt. This EdTech has been introduced to several countries globally, including countries of high-, middle-, and low-income status, is currently being scaled nationally in Malawi to support foundational learning of children in the first four years of all state

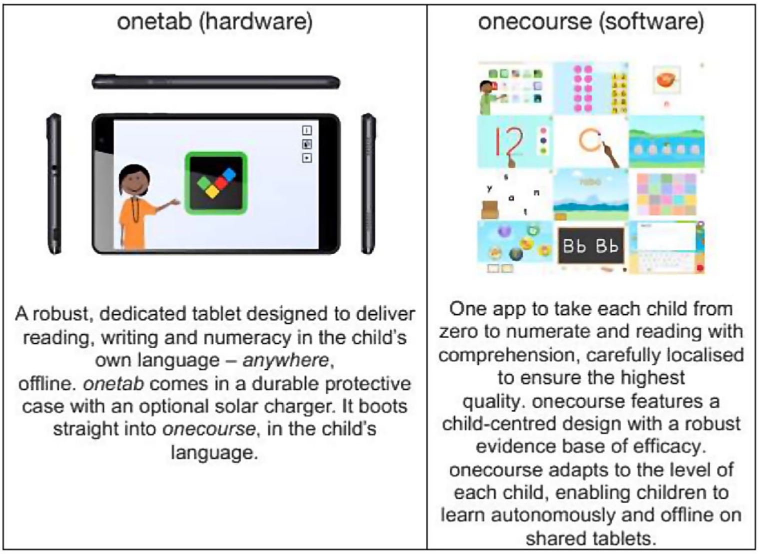

Fig. 1 Schematic illustration of the onetab hardware and onecourse software used in the personalised learning platform developed by onebillion, take from https://onebillion.org/ (permission granted)

primary schools[1]. Numerous impact evaluations have consistently reported significantly greater learning gains with this technology compared to mainstream education practice in several countries worldwide (see Pitchford, 2023a for an overview), and the technology has been shown to be effective at improving foundational learning for out-of-school children living in remote villages in Tanzania (Huntington et al., 2023b). Furthermore, research has shown that key pedagogical features known to be effective at improving foundational learning outcomes in school-aged children in different contexts are embedded within the onecourse software (Pitchford, 2023b; Outhwaite et al., 2023a). For example, Huntington et al., (2023b) found that onecourse encompassed a set of pedagogical features that promoted access to, engagement with, and the learning of foundational skills by out-of-school children in Tanzania. These features included autonomous learning, motor skills, task structure, engagement, language demand and personalisation. Moreover, a study by Outhwaite et al. (2023a) found that onecourse encompassed app features that promoted personalised learning, explanatory feedback, and motivational feedback; mechanisms shown to produce strong learning outcomes.

Previous research by Pitchford et al., (2018) explored the suitability of onecourse maths instruction by 33 children with SEND attending one of two learning units attached to one of two Malawian mainstream schools respectively. Results showed that although the onecourse maths content can be accessed by children with SEND, and children with SEND could progress through the software, utility was limited in promoting learning for children with severe functional difficulties, especially those with vision and hearing impairments and language difficulties. Further research by Lurvink & Pitchford (2023c) examined teacher and community perspectives of the use of this personalised digital learning platform by chil-

[1] https://www.imagineworldwide.org/updates/building-educational-foundations-through-innovation-technology-befit-malawi-scale-up-program-overview/.

dren with SEND in remote areas of Sierra Leone. Focus groups identified both opportunities and challenges for using this technology with children with SEND. Teachers reported the interactive touch screen technology helped children with SEND to learn to write and benefited slow learners as children could progress through the software at their own pace. The technology also supported the learning of children with sensory impairments, as children with vision impairments could move the tablet closer than the chalkboard, and children with hearing impairments could increase the volume to the level they required to engage with the learning process. In addition, teachers reported that children with cognitive difficulties who often do not respond to standard instruction attended and engaged well to the instructions and tasks delivered by the tablet, a finding replicated by a study of four children with Down Syndrome in the UK (Gulliford et al., 2021). Moreover, teachers, parents, and other community members in Sierra Leone reported that the use of this technology by children with SEND engendered a sense of belonging with their peers. However, several challenges were identified which focused on the risk of children with SEND damaging the tablet, the software being inaccessible for blind children, and the increased time management required by the teacher. Teachers also emphasized that children with SEND needed special attention and encouragement to engage with the software. Both teachers and community members expressed the need to have a special class or space for children with SEND, that is safe and where they are supported by trained teachers, so they can learn effectively with the technology. Clearly, this poses a fundamental challenge to the sustainable development goal of inclusive education articulated by the United Nations and demonstrates further how educational technologies can create additional barriers to inclusivity which increase inequalities for children with SEND (Barry, 2022). Consistent with other EdTech research on SEND, these studies reported on a relatively small sample size. To produce a stronger evidence base, there is a need for studies to involve a larger number of children and/or for a meta-analysis to be conducted to draw insights across different studies.

1.3 Current Study

As highlighted above, there remains a paucity of evidence on the utility of EdTech for children with SEND. Further, much uncertainty still exists about how EdTech can be designed to accommodate the needs of children with SEND. The current study addressed this knowledge gap by recruiting experts in SEND to participate in a formative evaluation of a particular EdTech that has been shown to be effective at promoting the learning of foundational skills (numeracy, literacy, and social-emotional skills) in young learners, in different contexts, globally (Pitchford, 2023). The study sought to identify possible adaptations that could be made to the onetab hardware and onecourse software to enhance equitable access and engender a more inclusive learning environment for children with a range of functional difficulties, based on the reviews of ten academic experts in SEND. The study sought to reduce barriers to learning by reviewing and improving the onetab and onecourse technology to respond to the individual needs of children with SEND. In undertaking this study, the following question was addressed: How do experts view the suitability of the onecourse software and onetab hardware for children with different functional difficulties and how might improvements to the technology enhance equitable access and inclusive education for children with SEND?

2 Methods

2.1 Design

To investigate the suitability of onetab hardware and onecourse software for children with SEND, a participatory, expert, semi-structured, formative evaluation was conducted. An exploratory qualitative research approach was deemed appropriate to provide data sufficiently rich as to inform instructional design decisions.

2.2 Ethics

Ethical Approval was awarded by the AUTHOR's INSTITUTION, in accordance with ethical guidelines of the British Psychological Society. Prior to study commencement, participants were provided with study information and consent to participate was gained.

2.3 Participants

Ten experts were purposefully selected based on their expertise in SEND. Pre-existing networks were used to select participants with relevant experiences and interests. The sample included academics from a range of backgrounds and years of experience, based at UK or Nordic universities. Expertise spanned Autistic Spectrum Disorders (ASD), Attention Deficit and Hyperactivity Disorder (ADHD), language disorders, sensorimotor difficulties, moderate and severe learning difficulties, deaf education, vision impairment, William's Syndrome, Down Syndrome, early years education, and applied educational and child psychology. Three participants had first-hand experience of education in LMICs. Participant received £500 for their contribution to the research.

2.4 Procedure

The study was conducted between March and May 2023. Figure 2 outlines the procedure followed. All participants received a onetab equipped with the onecourse software at the start of the study and attended a pre-review webinar which outlined the aims and objectives of the research as well as the participants' role in the formative evaluation. The pre-review webinar included input from the technology developers – onebillion – who walked through their hardware and software to familiarise participants with the educational technology and answer any questions participants might have. Following the pre-review webinar, participants were asked to engage with the technology individually, in their own time, and then complete a written technical review form. The technical review form included three main sections: what works, what hinders, and recommendations. In the first section, what works, participants were asked to comment on aspects they considered children with SEND would be able to interact with when accessing and engaging with the technology. In the second section, what hinders, participants were asked to comment on the challenges that children with SEND might encompass when accessing and engaging with the technology. In the third section, recommendations, participants were asked to suggest any adaptations that could be made to enhance accessibility and engagement with the technology. Participants were also asked to recommend additional technology or assistive devices, or pedagogical support, that

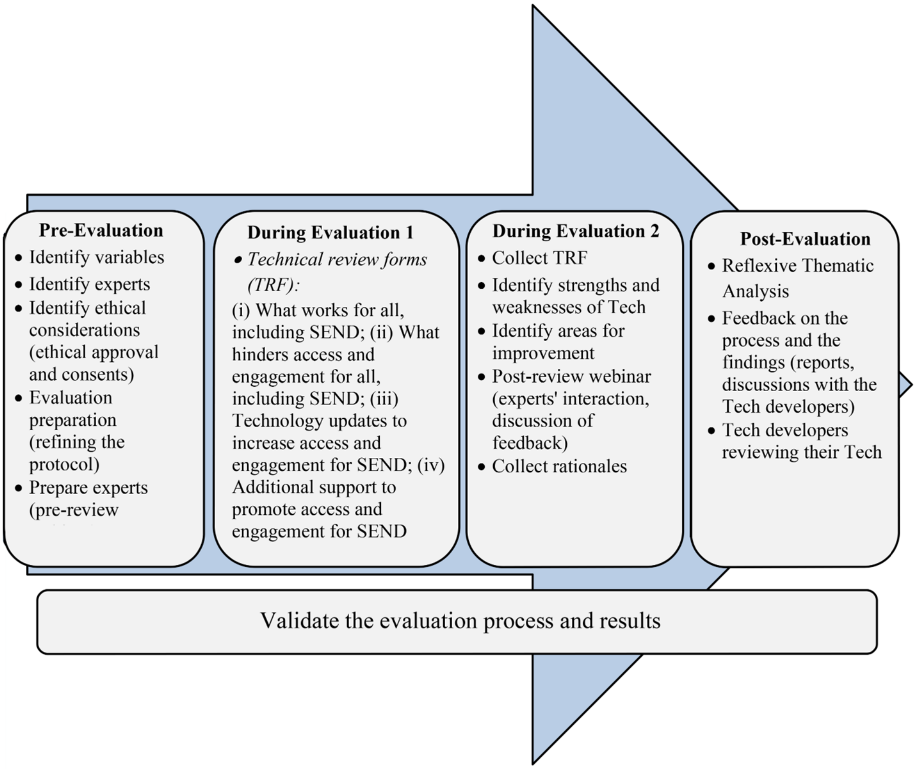

Fig. 2 Visual representation of the research stages involved in the formative participatory expert evaluation of the interactive, personalised, educational technology developed by onebillion

could be offered to improve accessibility and engagement with the technology by children with SEND. As such, the questions were developed to encourage participants to reflect on their perspectives and knowledge regarding children with SEND with the aim of providing focused and structured recommendations to improve the interactions of children with SEND with the technology and to minimise bias. After completing the technical review forms individually, participants were invited to attend a post-review webinar to discuss their feedback and recommendations with the other participants, researchers, and technology developers – onebillion. The post-review webinar was recorded and analysed.

2.5 Analysis

A reflexive approach to thematic analysis (Braun et al., 2018) was adopted to analyse the qualitative data collected. Reflexive thematic analysis (RTA) acknowledges the researcher's role in the production of knowledge (Braun & Clarke, 2019) and provides analytic and interpretative tools that help the researcher "to produce analyses from relatively straightforward descriptive accounts to more complex, theoretically embedded ones" (Braun & Clarke, 2022, p. 9). Although flexible, RTA is based on the intersection of the dataset, theoretical assumptions, and the researcher's analytical skills (see Byrne, 2022). Braun and Clarke

(2019) emphasise the importance of theoretical knowingness and transparency when implementing RTA. Therefore, it is crucial to report the theoretical assumptions upon which this research stands to outline "why the analysis is situated as it is and why this conceptualisation is appropriate to answering the research question(s)" (Byrne, 2022, p. 139). This research adopted a constructivist approach with the view that knowledge is socially constructed via exchange and interactions between individuals. The experiences and perspectives of the participants in this research were, therefore, constructed into knowledge through a reflexive process. Further, an inductive approach was adopted to emphasise the respondent/data meanings. On occasion, deductive analysis was adopted to ensure themes were relevant to the research question (Byrne, 2022). The first author followed Braun and Clarke's (2012, 2014, 2020) six-phase process in analysing the data. The technical review forms and transcribed group discussion data were coded using NVivo 12 software. Codes were then used to generate themes and sub-themes.

3 Results

Whilst the focus of this formative evaluation was onetab and onecourse, the rich data provided by the participants can be applied generically to inform theoretical and practical implications for designing, implementing, and evaluating the impact of educational technologies for children with SEND. As illustrated in Fig. 3, six main themes emerged from the RTA of the qualitative data obtained through the technical review forms and group discussion on the suitability of onetab and onecourse for children with SEND based on participants knowledge (i.e., research evidence) and experiences. Participants also made recommendations to improve the technology. The six main themes were: strengths of onetab and onecourse, supporting children with vision impairment, hearing, and functional difficulties, hardware updates (onetab), software updates (onecourse), boosting children's motivation, and the role of the teacher. While theme 1 focuses on the participants' perceived strengths of the technology, themes 2–6 shed light on the perceived challenges/weaknesses of the current

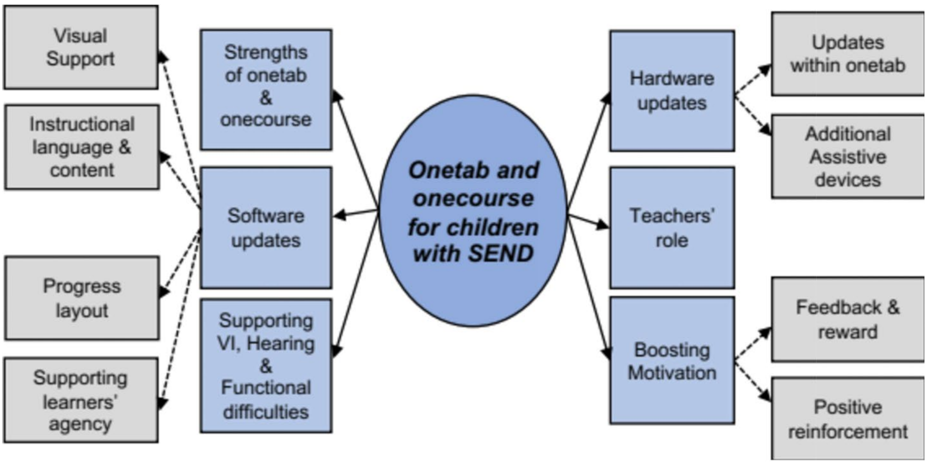

Fig. 3 Thematic map illustrating the results of the formative evaluation of the educational technology developed by onebillion to enhance use by children with SEND

technology and recommendations to improve the EdTech. Table 1 reports quotes and recommendations from participants across the six main themes and sub-themes. A summary of the key points raised for each theme and sub-theme is given below.

3.1 Theme 1: Strengths of Onetab and Onecourse

All participants saw merit in the onetab and onecourse technology in facilitating children's learning. They described onetab as being lightweight, fun, easy to access, visually accessible, and has great sound quality. Likewise, they found onecourse to be attractive, engaging, joyful, and accessible for children. They also noted that the technology had been designed to address technological issues that can be especially challenging in LMICs. (e.g., internet connectivity, electricity supply). Participants thought onecourse could be a promising tool for offering personalised learning, especially for children with SEND as it provides a range of activities that are crucial in developing functional skills, hand-eye coordination, attention, and learning. It also gives clear and straightforward instructions and "a good balance of challenge" across several tasks (RF2), offers good support through visual rewards, errors mediation, reinforcement, and auditory feedback, and the content is also culturally inclusive.

3.2 Theme 2: Supporting Children with Vision Impairment, Hearing, and Functional Difficulties

Participants were asked to comment on the challenges that children with SEND might have when accessing and engaging with the technology. As shown in Table 1, participants identified some technology features, tasks, and content that may present a barrier to children's engagement with onetab and onecourse. Most participants thought onetab would be inaccessible for children with vision impairment, children with fine motor function and coordination difficulties, and deaf or hard-of-hearing children, and some thought onecourse might be challenging for children with colour processing difficulties as many tasks are colour based. Several recommendations were provided to enhance access for children with vision or hearing impairment, and different levels of functional difficulties, as reported in Table 1.

3.3 Theme 3: Hardware Updates (Onetab)

Discussing challenges that children with SEND might have when accessing onetab led participants to suggest improvements to the device, which were categorised into two sub-themes.

3.3.1 Updates within Onetab

Suggestions included enlarging the font size and external volume buttons, ensuring easy volume control by children, and making the keyboard more responsive. Many participants felt that, unless updated, these features could decrease children's interest and motivation to interact with the technology.

3.3.2 Additional Assistive Devices

Participants highlighted that some additional assistive devices could be used to promote interaction by children with SEND with the hardware, as documented in Table 1. An interesting suggestion was to use a projector to allow "learners with low vision to see the images more clearly" (RF9) and connecting to external devices (via Bluetooth or plug in) to enable learners with different functional difficulties to use their assistive devices (e.g., "devices that could generate haptic pulses… or that could convert speech-to-text" (RF4). In addition, Augmented and Alternative Communication (ACC) devices were recommended as they "can help learners with difficulties with hand-eye coordination to be able to interact with some of the activities" (RF9). For children with cerebral palsy, coordination disorder, or reduced motor function "a screen holder which tightly holds the tablet in place. This can be screwed onto the learners' chair and placed low enough for them to touch the screen with their hands" was recommended (RF9) or a 'special' table to place the onetab on.

3.4 Theme 4: Software Updates (Onecourse)

Several software updates were deemed necessary by participants which were captured in the following sub-themes.

3.4.1 Visual Support

Participants felt improvements to the visual presentation of onecourse content and extra visual supports could improve accessibility for children with SEND (see Table 1). Participants emphasised that "cartoon imagery is not always helpful" and recommended including photographs of real-life objects and events to help children with ASD to "generalise learning and not just see as illustrations" (RF10).

3.4.2 Instructional Language and Content

Participants thought several aspects of the instructional language used in onecourse could be problematic for some children with SEND, as documented in Table 1, and recommended incorporating more varied and inclusive content, for example, by including more representations of children with SEND in the stories for "children to be able to identify themselves in the stories" (RF3). It was also suggested that topics such as health and wellbeing and making healthy choices would be of benefit to children.

3.4.3 Progress Layout

Participants identified a need to include a progress layout that would allow children to track task completion and celebrate achievement (see Table 1). They also recommended including creative and fun activities to provide an overview of the software, for example, by introducing an "avatar that a child can use to encourage them to go through each programme and also gives them an indication of when they are nearing the end of the cycle" (post-discussion) or "to have the virtual teacher Anna to walk the child through lessons" to increase "understanding and possibility to engagement" (RF3).

3.4.4 Supporting Learners' Agency

An important topic that arose was the need to design educational technology that could support learners' agency and group discussion focused on how much choice to give children. Participants argued that although choice can be worrying to some children with SEND, it is important to advance learners' agency. They suggested encouraging some choice (the idea of a play zone) without leaving the choice of learning topics completely to the child. Small alterations to the software, as described in Table 1, could enhance children's self-regulated learning. Furthermore, a series of pre-set 'routines' that "could be based on estimated time, or level of difficulty, or particular educational/ skills outcomes" (RF4) would create a good balance between agency and structure.

3.5 Theme 5: Boosting Motivation

Participants suggested that educational technology should boost learners' motivation to learn as it can be the "main drive for success" (RF7). They provided several suggestions to maximise the impact that onecourse could have on children's motivation, which were captured in two sub-themes (see Table 1).

3.5.1 Feedback and Reward

Participants suggested that the feedback used in onecourse could be improved by embedding differentiated and explanatory feedback to encourage children with SEND to progress through the software. Differentiated feedback aims to meet the diverse needs of learners with SEND whereas explanatory feedback aims to reinforce understanding by informing the learner as to why a particular answer is considered correct or incorrect. Feedback should be accompanied with exciting and immediate rewards, as this would be of particular benefit to children with ADHD.

3.5.2 Positive Reinforcement

To embed knowledge, participants reasoned that educational technologies should provide auditory repetition and rehearsal of foundational skills, which can be mutually supportive in this context as repetition and positive reinforcement can increase learners' motivation. In addition, reminders and breaks should be prompted throughout the learning sessions, which could be especially useful for children with ADHD.

3.6 Theme 6: The Role of the Teacher

Participants saw the role of educational technology as supporting teacher-student interactions and provided several suggestions about how onetab and onecourse could be adapted to facilitate the role of the teacher in children's learning, with special attention to SEND (see Table 1). Although some participants argued that onecourse, as it is currently designed, could effectively scaffold with an untrained adult, others argued that adults required training to increase their awareness and knowledge of how the software can be used effectively by children with SEND. According to some participants, if adults are not trained, they might consider that “disabled children have reduced abilities to engage and/or access, and then either children are placed on devices excessively or not given access” (RF1). Furthermore, participants suggested that training would allow teachers to adapt onecourse to develop their own lessons based on the needs of individual learners.

4 Discussion

Despite increasing use of EdTech in different learning settings, there is limited research evaluating its utility for children with SEND. Taking the SDG4 into consideration, this study sought to explore experts’ views and perspectives regarding the suitability of a personalised, interactive, educational technology – onetab hardware and onecourse software – for use by children with SEND. Themes generated from the data demonstrated a range of perspectives, based on empirical evidence from the literature, and the experiences of participants in supporting the learning of children with different types of functional difficulties. The study findings are summarised and discussed in the following points: (i) strengths of the built-in functions of the EdTech under investigation; (ii) promoting technology-enhanced personalised learning; (iii) adaptations to meet the needs of children with severe difficulties; (iv) promoting ‘access to technology’ and ‘technology to access’ through onetab and onecourse; and (v) designing EdTech to empower learners’ agency.

Our results showed that participants found the technology to be exciting, easy to access, and provides interesting learning activities. These features should facilitate learning of foundational skills for all children as they are based on the principles of universal design (The Center for Universal Design, 1997). The participants’ views were consistent with findings of Pitchford, (2023) highlighting that the educational technology evaluated in this study comprises software that is delivered through touch-screen tablets, which are mobile and lightweight and eliminate the need for extra dexterity-reliant devices (e.g. keyboard and mouse) (Kucirkova, 2014) and includes a wide array of multisensory representations of information (such as pictures, sound, video, and animation), interactive tasks of varying degrees of difficulty, clear goals and rules, learner control, response feedback, and repetition. These findings accord with other studies showing that such features promote personalised learning, with little or no adult support (Condie & Munro, 2007; Hardy & McLeod, 2020; Rose et al., 2005). Further, our findings broadly support the work of other studies in this area associating the built-in functions of onetab with the increase of access to learning among students and children with SEND (Banes et al., 2019).

A key objective of this study was to identify areas for improvement for onecourse EdTech based on perceived weaknesses with the current technology. In this study, personalised learning was deemed crucial to promote an inclusive EdTech. In accordance with this finding, previous studies demonstrated the important role that technology-enhanced personalised learning plays in improving children with SEND’s access to learning (Major & Francis, 2020; Major et al., 2021). To promote personalised learning via technology, participants stressed the importance of adapting software instructions and tasks to the needs and abilities of individual learners. Suggestions focused on creating a screening survey to produce learning profiles that adjust to the child’s level of functioning, tailoring learning opportunities to the needs of individual children, encouraging learners to make choices, and including differentiated feedback. This is important as previous research has suggested

Table 1 Quotes and recommendations from participants across the six main themes and sub-themes. RF refers to data garnered from the review forms for the corresponding participant number; PD refers to data generated through the participants discussion

Supporting Quotes	Recommendations
Theme 1: Strengths of onetab & onecourse	
• "The children will enjoy having a device to explore that is colourful and fun" (RF1). • "The interactive nature of the software… is one of the strengths of the software" (RF5). • "It is great in the way it adapts the lesson to the child's level" (RF3).	Keep these features as they are known to support learning
Theme 2: Supporting children with VI, hearing & functional difficulties	
• "Engagement for deaf children given the lack of subtitles and the lack of visual support is really difficult" (RF5). • "Largely inaccessible for learners with severe vision impairment (non-print readers)" (RF6). • "Some learners with moderate to severe physical difficulties, which cause limited use of their fingers and hands… will find it difficult to swipe and drag" (RF9).	• Enable lip reading by including a real person to give instructions instead of a cartoon teacher. • Provide an option of captions. • Include a screening survey to produce a learner profile that accommodates to the child's functionality. • Categorise onecourse activities into functional features/ interactive features (e.g., drag and drop, tap, and speech) to allow an adult (teacher) or the software to select tasks that are suitable for the individual learner.
Theme 3: Hardware updates (onetab) **Sub-theme: Updates within onetab**	
• "The external volume buttons are small and having no 'click' may be harder to manipulate without good fine motor skills" (RF2). • "For children with vision impairments the tab could have buttons, maybe with figures or braille" (RF3).	• Enlarge the external volume buttons. • Ensure an easy volume control for children. • Enlarge the font size. • Make the keyboard more responsive. • Disable tab functions that could distract children with SEND (e.g., camera function, web searching). • Make the hardware accessible for children with VI by adding buttons to onetab (with braille or figures).
Sub-theme: Additional assistive devices	
• "The device needs to be amended to enable deaf children to pair their hearing aids/ cochlear implants to the device" (RF5).	• Issue a stylus with the tablet. • Use headphones that direct the sound straight into ears. • Screen projection to a larger device. • Include Augmented and Alternative Communication (ACC) devices. • Use a screen holder and/or special table to place onetab on.
Theme 4: Software updates (onecourse) **Sub-theme: Visual support**	

Table 1 (continued)

Supporting Quotes	Recommendations
• There is a need for a "greater control over visual presentation" (RF6). • "Visual supports within activities […] at least as an option should be provided to make onecourse more accessible for autistic children" (RF8). • Scaffolding "through the use of symbol-based curriculum" (RF2).	• Enhance the visual presentation (e.g., enlarging the font, higher contrast options). • Provide visual support within activities. For instance, use pictures to "reinforce/ offer multimodality for the text rather than additional information" (RF6). • Include photographs of real-life objects and events instead of cartoon imagery. • Use symbol-based curriculum (e.g., storyboards, images).
Sub-theme: Instructional language & content	
• Long instructions "could impede the understanding and the engagement" of children with SEND (RF2). • Some of the activities "assume a lot of vocabulary knowledge which deaf children would struggle with" (RF5). • "I would love to see more children with disabilities represented in the stories" (RF3). • "Several neurodiversities struggle to identify 'like' sounds and a lot of the early English course relies on it" (RF10).	• Use simple, short, pictorial instructions. • Include more units on health and wellbeing, online safety, making healthy choices. • Include learners with SEND in the stories and images. • "There needs to be a way that sound can be discriminated more accurately" (RF10).
Sub-theme: Progress layout	
• "The learner would benefit from a means to monitor and celebrate their progression" (RF2). • "The child would have to keep track of what units they have done so far and which ones to do next" (RF7).	• Have the virtual teacher Anna or an avatar to walk the user (the child) through the session. • Add some approaches to communicating progress with reference to an end-point (e.g., a progress bar).
Sub-theme: Supporting learners' agency	
• "The child might/should still choose/be able to choose a different unit/game but suggesting a unit based on previous performance will mean that the child will make more progress" (RF7).	• "Some part of agency is being able to choose when to pause or stop, and it being clearly OK to do so" (PD). • Allow children to pause and/or exit a task when needed (e.g., include a back button to go back to the main menu/screen) • Include options for shorter sessions.
Theme 5: Boosting motivation **Sub-theme: Feedback & reward**	

Table 1 (continued)

Supporting Quotes	Recommendations
• The onecourse software should provide "more exciting and engaging feedback" (RF1). • The software would benefit from "a more immediate and exciting reward for completion of tasks… to engage children with limited attention" especially that "children with inattention and/or ADHD lack dopamine and so require consistent and quick motivation" (RF10).	• Avoid negative tone in feedback. • Avoid reinforcing incorrect associations. • Include two types of feedback. **Differentiated feedback**: "If the child does very well (accuracy and speed), they should get 'excellent' (word, sign or ideally both) and when good, they should get 'you are doing well/ that was good'' (RF8). **Explanatory feedback**: "include an explanation why the answer is correct or incorrect" (RF5). • Include immediate and exciting feedback (e.g., allowing children to build their avatars).
Sub-theme: Positive reinforcement	
• "For children with SEND motivation is a main drive for success" (RF6). • There is a need for "positive reinforcement" (PD).	• Provide more rehearsal of foundational skills and auditory repetition. • Include opportunity for the child to immediately repeat the unit. • Focus on positive reinforcement. • Include more videos to watch
Theme 6: The role of the teacher	
• Educational technologies "should not be seen as a replacement for teachers" (RF1). • "The presence of an adult [teacher] working within the scaffolding offered by the software could help children with SEND stay on track, circumvent some access issues, and become less frustrated" (RF6).	• Educational technologies should support teacher-student interactions. • Train teachers to support children when using educational technologies. • Allow teachers to select activities/tasks based on the needs of their individual learners. • Encourage teachers to provide "external rewards that are more relevant to each child's special interest" (RF8). • Include a video of instructions for teachers to access on onetab.

that technology-supported personalised learning has a positive impact on learning outcomes (see Major et al., 2021) and that personalisation is a key pedagogical feature for enhancing learning outcomes for children in different contexts (Outhwaite et al., 2023a; Major et al., 2021; Huntington et al, 2023b). This corroborates the findings of Lurvink & .Pitchford (2023c), who showed that onecourse offered a flexible and effective method of instruction for children with SEND in Sierra Leone. Moreover, participants noted that the design of onetab and onecourse should address technological issues that can be especially challenging in LMICs. This is important as previous studies have suggested that challenges to internet access, electricity supply, and hardware can hinder the promise of educational technologies in LMICs (Hennessy et al., 2022). As this technology is being introduced to several LMICs and is being scaled nationally in Malawi to all state primary schools, it is critical that it encompasses design principles that can accommodate challenges with infrastructure, as well as enabling equitable access for children with SEND. Going beyond previous findings, our results provided insights on *how* to make this technology more accessible and inclusive for children with SEND, as discussed below.

To engender the most promising outcomes, educational technology should accommodate the abilities and needs of all learners, yet evidence is weak for the efficacy of raising learning outcomes of children with SEND through technology (Lynch et al., 2022). With regards to onetab, in accordance with previous research in the field, our results demonstrated that several adaptations are required to ensure that children with vision or hearing impairment and children with functional difficulties can access and engage with the technology. For example, using visual aids, as these are known to facilitate learning of children with SEND (Sperotto, 2016), and improving the quality of sound discrimination, as some children with SEND (e.g., dyslexia, ADHD) exhibit difficulties with sound discriminations (Thiede et al., 2019). Previous research by Pitchford et al., (2018) found the onecourse maths content to have limited utility for children with severe difficulties, especially those with sensory (vision and hearing) impairments and language difficulties and that was highlighted again in this study. In accordance with previous studies, our findings suggested that assistive devices might be necessary to use in conjunction with educational technologies for children with severe difficulties, as they are known to increase accessibility (Fernandez-Batanero et al., 2022; Banes et al., 2019). Another suggestion was to use a projector to increase the size of the visual display. This is interesting as Lurvink ' Pitchford (2023c) reported on a pilot study in Sierra Leone that trialled using a projector to boom the onecourse software to a white board/wall so it could be used for whole-class teaching. Results showed this novel method of implementation improved grade 1 children's learning of foundational skills significantly more than control children who received standard classroom practice, but the learning gains with this whole-class implementation method were less than other implementation methods centred on individualised learning with the software. However, if shown to support the learning of children with SEND, as well as their mainstream peers, this whole-class implementation method may be a cost-effective way of scaling this educational technology, especially in low-resource settings.

Further, the findings reported in this study provided a deeper insight into developing onetab and onecourse to support 'access to technology' and 'technology to access', which align with the notions of 'access to learning' and 'learning to access' proposed by Douglas et al. (2019). In this regard, 'access to technology', aims to create an inclusive learning tool that can be accessed by all learners. Developing children's access to technology, based on our findings, requires providing within-software access strategies (e.g., adding captions, enlarging font size, adding buttons with braille) and additional support (e.g., teacher and pedagogical support). In contrast, 'technology to access' aims to create technology that promotes children's social-emotional learning, motivation, engagement, and agency. Developing technology to access, as suggested by our findings, requires including explanatory and differentiated feedback, immediate and exciting reward, inclusive content, and a degree of agency. This corroborates research by Park and Ertmer (2008) who highlighted insufficient feedback as one of the barriers faced when implementing technology-enhanced problem-based learning. In addition, previous studies identified explanatory feedback and motivational (exciting) feedback as key mechanisms that maximised learning outcomes of children when using interactive maths apps (See Outhwaite et al., 2022, 2023b). Thus, although the suggestions to incorporate strategies to develop 'technology to access' support the work of other studies, our empirical findings extended our understanding of developing and differentiating between 'access to technology' and 'technology to access'.

Learner agency is known to impact academic success in different settings (Luo et al., 2018; Code, 2020; Taub et al., 2020). Consequently, there have been calls to design technology that empowers learners' agency (e.g., Tchounikine, 2019), however assignment of agency can be problematic and technology developers often struggle to decide on how much choice to assign to learners in the software (personal communication with onebillion). Our results suggest that adaptive assignment of agency, as suggested by Brod et al. (2023), is required to maximise learners' agency via the use of educational technology. Adaptive assignment of agency refers to allocating different levels of agency to individual learners based on their needs and characteristics. Adaptive assignment of agency allows technology to strike a "balance between too much agency, which leads to ineffective learning, and too little agency, which hampers learners' motivation and development of self-regulated learning skills" (Brod et al., 2023, p.14). Regarding onecourse, the software creates personalised profiles for every learner, and it was suggested that these could be adapted to give learners different levels of agency (choice). Hence, our findings provide new understanding of practical strategies to promote agency through technology. Linked to agency is motivation. Our results suggest that embedding differentiated feedback, and an exciting reward system, within personalised software can increase learners' motivation. As outlined above, effective use of feedback has been identified as a key mechanism for promoting learning outcomes with educational technology (Outhwaite et al., 2022). However, little attention has been paid in current research to investigating the link between technology-supported personalised learning and motivation of children, especially those with SEND.

Our results also indicated that teachers are instrumental in controlling agency and promoting equitable access to technology-supported personalised learning for children with SEND, not only in facilitating engagement and accessibility, but also in the personalisation of learning. However, this result has not previously been described in research. As suggested by Major et al. (2021), for technology to empower teachers to implement personalised learning, it is important to equip teachers with the training and resources they need. This was also highlighted by Lurvink & Pitchford (2023c), who reported that teachers in Sierra Leone required specific training in using educational technology with children with SEND, to maximise the support they offered based on the needs of individual children to enhance learning.

The participants' discussion of the EdTech challenges/weaknesses and their recommendations for updates demonstrated that the EdTech under evaluation in this study in its present form poses some difficulties for children with SEND and, therefore, adaptations to the software and its implementation are required to accommodate the needs of children with SEND. These results reflect those of Gulliford et al., (2021) who suggested that onecourse, in its previous version, was inaccessible for children with VI and that children with SEND required special encouragement and attention to engage with it. It is interesting to note that the qualitative findings in this study did not raise social-emotional learning as a key theme and it is yet unclear how the EdTech under investigation can support the social-emotional learning of children with SEND. Nevertheless, the EdTech developers are aiming to strengthen onecourse to support social-emotional learning of children with SEND.

4.1 Research Contribution

As outlined above, this study focused on examining experts' views regarding the suitability of an EdTech- onetab hardware and onecourse software- for children with SEND. The study addresses the gap in knowledge highlighted in the introduction and extends academic knowledge by identifying inclusive EdTech strategies and practices. The present study contributes to the literature by providing deeper insights into the views of SEND experts and their perspectives on the suitability of the use of EdTech for children with SEND. Therefore, the study addresses a gap in knowledge regarding SEND experts' views on using EdTech to support learners with a range of functional needs. Although the evaluation focused on a particular EdTech, it provided a big picture of how EdTech should be designed to support inclusive and equitable quality education. The practical strategies and suggestions provided in the study should help to improve design knowledge for researchers and EdTech developers to develop inclusive EdTech. If the recommendations highlighted in this study are incorporated in future EdTech design, this will enhance the usability of EdTech not only for children with SEND, but for all learners, including those in mainstream education. This study also identified several EdTech inclusive practices that have not been examined previously. Based on the review of the literature, there is a lack of research that focuses on the utility of EdTech for children with different SEND. Our study has gone some way towards enhancing understanding of the challenges that EdTech pose for children with severe difficulties and has provided suggestions for improving 'access to technology' and 'technology to access'. Our findings add to the growing body of research that stresses the importance of agency, explanatory feedback, differentiated feedback, immediate and exciting feedback, positive reinforcement, inclusive content, and use of visual support in promoting the participation of all children. This study thus extends knowledge in the field by identifying practical strategies to address these learning needs. Insights gained from this study may be of assistance to research into designing EdTech and assistive devices for children with VI, hearing, and functional difficulties. Hence, the study provides design solutions to EdTech developers, that if implemented, could carve the way for interactive, technology-supported personalised learning, to become a future role model within SEND education that could be scaled globally.

The present study also offers an important methodological advancement through the design and implementation of a semi-structured formative participatory expert evaluation of an educational technology, that can be applied to other technologies and domains. As described in Fig. 2, the process was characterised by engagement of experts in the evaluation of an educational technology with the aim to (i) increase the scope and depth of evaluation; (ii) increase the transparency of evaluation; (iii) acknowledge the educational aspect of evaluation; and (iv) foster the interaction between academic experts and technology developers in the evaluation process. Further, the semi-structured nature of the process allowed us to manage biases and direct the experts' focus to (i) areas of improvement, as required by the technology developers, and (ii) changes to the technology, required to achieve the 2030 Sustainable Development Goal for Education. The technology developers found this methodology efficient and informative (personal communication with onebillion) as it generated clear guidelines and evidence-based recommendations on how to enhance the reach of the technology to increase equitable access and inclusive education for all.

4.2 Study Limitations

While this study confirmed the potential of onetab and onecourse in promoting access to technology-supported personalised learning and offers a number of strategies that can be adopted by EdTech developers, it is subject to certain limitations. First, although this study is the first to involve experts in SEND in evaluating EdTech, it did not explore the experiences of children with SEND and their perspectives regarding the utility of the EdTech. The study thus lacks the voices of the students who will use the EdTech to support their learning. The lack of involvement of the beneficiary has been identified in other studies reviewed by Lynch et al. (2022) and clearly needs to be addressed in future research. Second, a further limitation of this study is that the participants were based at UK or Nordic Universities. We acknowledge that the participants' perspectives and experiences may be shaped by contextual factors and national educational systems. For these results to be generalisable, further research might focus on the experiences and the perspectives of children with SEND and experts from different contexts and education systems in which the EdTech is being deployed.

5 Conclusion

Given the rapid technological advancement in the field of education and in accordance with SDG4, this study aimed to investigate the suitability of an interactive, personalised, EdTech-onetab hardware and onecourse software- for use by children with SEND. To achieve this, a participatory formative evaluation was conducted with 10 experts in SEND. The study yielded significant findings regarding the strengths of built-in functions of the technology under investigation. Further, the findings provided deeper insight into the software limitations/weaknesses and required updates to meet the needs of children with VI, hearing, and functional difficulties. Interestingly, the findings suggest the need for promoting technology-enhanced personalised learning into the education of children with SEND, by incorporating adaptations to meet the needs of children with severe difficulties, promoting 'access to technology' and 'technology to access' through onetab and onecourse, and designing EdTech to empower learners' agency.

In summary, this formative evaluation has revealed how adaptations to onetab and onecourse could promote equitable access to technology-supported personalised learning to engender inclusive education for children with SEND. Our results suggest that EdTech can deliver on the promise of being accessible, inclusive, effective, and engaging if it affords tailored personalised learning that offers different levels of agency. To realise this potential, future research needs to investigate the interactions of children with SEND with interactive personalised learning technology in different contexts and learning settings, to establish if this technology could be a role model for SEND education at a global scale.

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Data Availability Anonymised data presented in this study is available upon reasonable request to the second author.

Declarations

Ethical Approval Ethical approval for this study was granted by the University of Nottingham Ethics Committee [ref: F1419].

Consent to Participate Consent to participate was obtained from all individual participants included in the study.

Conflict of Interest Consent to participate was obtained from all individual participants included in the study.

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