Aliens, Tangibles & Chatbots: Co-designing Inclusive Educational Technologies with and for Children with Mixed-Visual Abilities

Oussama Metatla
University of Bristol
Dept. of Computer Science
o.metatla@bristol.ac.uk

Clare Cullen
University of Bristol
Dept. of Computer Science
c.cullen@bristol.ac.uk

Taimur Ahmed
University of Bristol
Dept. of Computer Science
ta16969@bristol.ac.uk

Abstract
We present initial findings from the Crossmodal Interactive Tools for Inclusive Learning (CRITICAL) project, which aims to research and develop inclusive educational technologies to make group work in mainstream classrooms more inclusive of children living with visual impairments (VIs). We argue for the need to develop effective inclusive co-design processes that engage educators and both children with and without VIs to conceptualize inclusive technologies in this space. We outline findings from a field study highlighting potential barriers to inclusion that could be a direct product of existing educational support structures in mainstream schools, which we identified as *"teaching assistant bubbles"*, and explore themes of alternative collaborative educational technologies, including multisensory storytelling and straddling mixed-reality enabled via tangible displays, and interactive conversational agents in voice-user interfaces.

Author Keywords
Mixed-ability, Mainstream Education, Visual Impairments, Co-design, Inclusion, Multisensory Interaction, Voice-User Interfaces

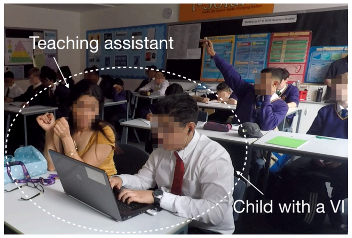

Figure 1: A child with a visual impairment sitting with their teaching assistant in a mainstream classroom. Often, we observed that this close interaction could lead to the formation of what effectively amounts to a separate lesson that has its own material, scope and pace, and that could gradually lead to detachment of the child with VI from the main activities taking place in a given lesson.

ACM Classification Keywords
H.5.2 [User Interfaces]: Prototyping, User-centered design; K.3.1 C [Computer Uses in Education]: Collaborative Learning; K.4.2 [Computers and Society]: Social issues - Assistive technologies for persons with disabilities.

Introduction
The inclusion of children with Special Education Needs (SENs) in mainstream education is a growing trend, commonly supported by supplementary policy and implemented with the aid of specialist personnel and tools. However, recent research suggests that the integration of SENs in the mainstream is sub-optimal and further instances of reliable and effective practice need to be developed [1]. Tools used to make accessible learning experiences, such as Braille, tactile diagrams, screen readers and magnifiers, are by design to be used by pupils with VI's as opposed to their sighted peers who lack the specialist skills; possibly leading to learning in isolation and reduced opportunities to collaborate or engage with peers [2,3]

A twofold issue thus seems apparent; an increase in integration of technology in the modern classroom, coupled with an emphasis on accessibility as opposed to inclusion. We suggest that by understanding inclusive learning environments and devising appropriate and relevant approaches for designing technology, an alternative and possibly complementary approach to augment learning environments with technologies that take into consideration the mixture of abilities and processes surrounding groups and individual learning can be arrived upon.

Young stakeholder involvement in technology design and resultant methodologies are well established [e.g. 4] and active research regarding SENs in domains such as education is underway [e.g. 5]. However there is a lack of research into co-designing with children who are blind or live with VIs in a process that also involves their sighted peers [6]. In our ongoing project, entitled *Crossmodal Interactive Tools for Inclusive Learning* (CRITICAL), we aim to address the question of how technology can intervene in meaningful ways to improve inclusion in mainstream education, making two main contributions to this body of work: First, by characterising barriers to inclusion of children with VIs in mainstream schools, offering extra insights into the role of the teaching assistants in balancing dependence and inclusion for these children. Second, by demonstrating how engaging children and educators through inclusive co-design methods enable joint production of radically new conceptions of inclusive educational technology.

Teaching Assistance "Bubbles"
Based on insights from a 10-months field study involving class observations and interviews with educators and children with VIs [3], we suggest that enhancing inclusive learning environments with technology should aim to target a variety of sensory modalities to promote opportunities for joint attention and shared experiences between pupils with and without VIs; to scaffold the prevalent maker culture among educators; and to improve and promote independent mobility for children with VIs. These insights are consistent with recent developments in this domain (e.g. [7]). However, our findings extend existing work by emphasising the potential adverse effects that over-reliance on teaching assistance could

Figure 1: Top: The story-wave prototype for recording and playing narrative segments with capacitive touch sensing; Bottom: Tactile grid using different textures

Figure 3: The boxes of characters for the story-building activity

have on any technology developed to target these potential areas of intervention. The close interaction between TAs and children with VIs is crucial to their learning in inclusive classrooms and is a characteristic feature of their mainstream learning experience [8]. But a number of factors in the learning environments we observed showed how such structures could morph into "an assistance bubble" (Fig 1), one that has its own material, scope and pace, that could isolate the pupil from the rest of the classroom. We argue that designers should actively avoid designing technology that consolidate the undesirable effects associated with such support structures.

Bursting the "Assistance Bubble"

We are currently employing a methodology blending co-design and in the wild evaluations to develop and research the design of technologies that would actively avoid the potential adverse effects associated with "teaching assistant bubbles". We outline our explorations of the potential of two such technologies; tangible multisensory storytelling and collaborative learning enabled through voice-user interfaces.

Multisensory Storytelling Platforms

In group work around storytelling, schools often use story maps and story posters, which are difficult for children with visual impairments to access, further enforcing overreliance on teaching assistants to bridge material and social gaps surrounding this learning activity. To address some of these issues, we have been working with a group of children with visual impairments and their sighted peers to design a multisensory joint storytelling platform [3]. To date, we have run preliminary workshops with educators and children (aged 8-9 years) to establish the main requirements and ideas for this collaborative system. During the design activities, we have used techniques such as fictional inquiry [9], future workshops [10] and bags of stuff [11] (presented in a more accessible format as a *"box of multisensory stuff")* to engage all stakeholders in design. The sessions so far have explored these design ideas, at the same time as facilitating the children's learning of storytelling components, including narrative construction and development, characters and settings (Fig 2-3). Ongoing work explores other important aspects of the multisensory storytelling: integrating audio i/o and effects for narration and dialogue, the use of sound effects and soundscapes, olfactory arrays, tactile aspects (texture, form, vibrotactile cues), and visual aspects (lights, colour).

Conversational Voice-User Interfaces and VIs

Conversational voice-user interfaces such as Amazon's Echo devices have recently opened up an exciting design space to understand aspects of how people interact with conversational voice agents [12]. We are exploring this design space by focusing on its implication within an education context and to assist mainstream education of SENs. In particular, we are developing a Mixed-Reality experience with a conversational interface in the center of a tangible multisensory table top to enable collaborative and personalized learning experiences between children with and without VIs (Fig 4). Our aim is to use the interface to enable an ecosystem of personalities or 'helper chatbots' augmented with tangibles and abstracted as per their desired functionalities. The underlying aims of this technology is to tentatively

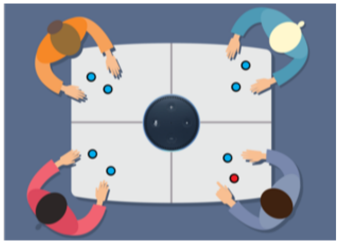

Figure 4: Conceptual explorations of collaborative education mixed-reality experience with Amazeon Alexa as a central conversational interface and interactive tangibles that implicitly encourage turn taking between children with and without VIs

Figure 5: Co-designing interactive tangible interaction with chatbots for notetaking and revisions with children with and without VIs

enhance SEN mainstreaming pedagogies and improve learning, collaboration and turn taking. During introductory sessions with educators and children with and without VIs, we explored initial prototypes to introduce voice capabilities, the persuasiveness of the technology and its potential applications in mainstream classrooms. Ongoing work beyond the application of helper chatbots considers the cognitive aspects of note taking for pupils with VIs through the conversational interface, implemented as a medium for storing and recalling notes from a tangible constructive assembly.

Conclusion

We suggest that the design and development of technology that aims to improve the inclusion of children living with VIs in mainstream education should take into account how such technology would be embedded within existing support structures, e.g. teaching assistance, and in particular, designed to avoid consolidating the potential undesirable effects associated with such support structures. We advocate an inclusive co-design approach involving educator and both children with and without VI in the development of such technology, and we are currently pursuing the potential of multisensory tangible displays and voice-based user interfaces in this context.

Acknowledgements

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