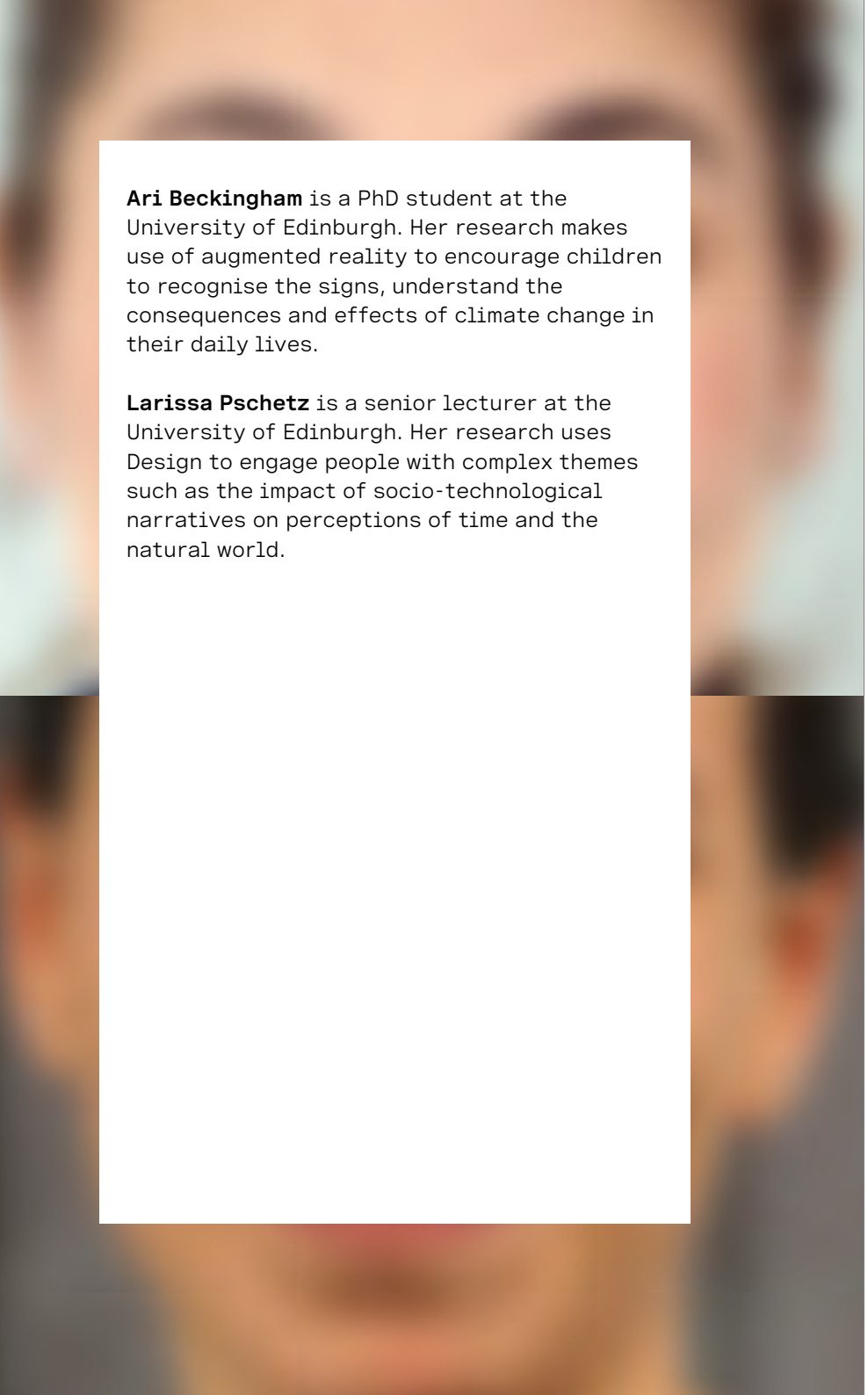

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Rethinking pace, context and modes of learning in EdTech design

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The coronavirus (COVID-19) pandemic created an urgent demand for digital technologies to support children's remote learning and socialisation needs. With lockdowns and school closures, many children started to adopt digital platforms and applications to carry out school, social and extracurricular activities. Formal learning gained new informal and unstructured characteristics, as it started to take place across multiple settings and relied more on (sometimes also revealing the lack of) support from parents (including caregivers) and other groups beyond the school.

However, most technologies adopted for learning during the pandemic were not designed for such a purpose. For example, video conferencing platforms (e.g., Zoom and Microsoft Teams) were designed to support adult engagement and productivity, often with office-based environments, routines and etiquette in mind. They tended to be context-agnostic, treating physical environments as either irrelevant or a distraction to the learning activity, rather than an important aspect of learning. Importantly, these technologies assumed an awareness of practices and implications of data recording and sharing, which children (and many adults) indeed often lack.

Here, we argue that designers could start rethinking

educational tools for remote learning by considering different paces and modes of engagement, connection to different contexts and physical and social environments, as well as increased awareness of data processes and practices. We further discuss how design considerations, combined with emerging technologies such as augmented reality (AR), could help create a renewed agenda for EdTech (educational technologies) design. The intended benefit of rethinking learning tools in this way is to expand the breadth of learning tools and possibilities, without compromising on transparency and ethics of data processing. However, the possibility of improved learning outcomes to result from our suggested design considerations, especially in relation to the use of AR, remains difficult to measure.

Considering more nuanced approaches to pace and engagement

A key aspect of technology design is a recurrent focus on productivity (Hallnäs & Redström, 2001; Odom et al., 2012), which usually translates into keeping people engaged, focusing attention towards accomplishment of specific tasks, and optimisation of time spent on these tasks. While such assumptions can be problematic in general (Pschetz & Bastian, 2018), when applied to children's technologies, they can be hazardous. Addiction to technology usage among children and teenagers is a common concern in the literature (Hawi et al., 2019), with studies suggesting links between greater time spent online and reported feelings of loneliness as well as lack of physical activity and disrupted sleep (Nalwa & Anand, 2003). Coban (2020) discusses that even well-meaning EdTech, such as video-animated storybooks, which help keep students engaged in stories and where they can practise reading with or without adult supervision, can lead to a slippery slope of dependency on technology, especially with young children who are at a vulnerable stage of development.

As reported by the 5Rights Foundation (2021a), there is a culture among companies of generating revenue by maximising the retention, reach and activity of children, which may sacrifice their safety and wellbeing. As such, designers have been designing interactions, interfaces and content for 'more time, more people, more activity' (5Rights Foundation, 2021b), leaving children feeling that they are spending too much time on their devices, that they have too much exposure and/or feel too much pressure to get engagement on their profiles.

Some designers have been advocating for a change of practice, for example by exploring whether less engagement could translate into longer term relationships. Challenging assumptions of success in the industry is a way of treating the symptom of a wider issue of following the narratives of success in design as a whole. This would open up space for exploring different qualities of engagement and new modes of interaction (e.g., by exploring boredom, including attention breaks, and supporting connection to the environment).

A different approach to engagement is exemplified by the PlayStation games Flow (2008) and Journey (2012), which invite players to slow down while exploring a scenic virtual landscape. Exploration is the main aspect of the game, and players interact with each other through a quiet mode of communication - when they meet in the game's virtual environment, they can only communicate by emitting bird-like tweets, rather than through words or text. These games invite slowing down and offer a meditative experience rather than focusing on task completion, competition and active communication.

The consideration of more nuanced notions of pace and engagement allows for incorporation of multiple aspects of children's experience, which can be a starting point for creating radically novel interfaces and learning experiences, while providing alternatives for exploitative models of technological development.

Rethinking context

During the COVID-19 pandemic, technologies widely adopted in formal education focused on keeping communication channels open. In this context, children's physical environment was either disregarded or treated as background noise to the mediated interaction. While supporting communication is important, children could indeed benefit from technologies that take their social and physical environment into account.

Research shows that learning can be improved when

applied across different locations, representations and activities, and immersive technologies can have a key role in promoting retention, communication and engagement (Luckin et al., 2012). According to research by Zimmerman and Bell (2012), learners' performance and competency faltered when in a formal setting such as school, over an informal setting such as out-of-school programmes. Mediated cross-setting learning could therefore improve education, beyond the need to accommodate for self-isolation. It could support capturing, storing, comparison and integration of data from several places and contexts, while also keeping groups in and out of different processes through multiple ways of sharing and communicating. Furthermore, due to the accessibility of devices such as mobile phones, and students' immediate access to capturing, storing and managing data (e.g., images, audio and video), children have the opportunity to view their learning material from a variety of different perspectives (Furió et al., 2015).

The introduction of context, however, cannot be taken lightly. The environments children are in can make or break learning, and research has shown that remote learning can contribute to reinforcing differences between the well-supported and ill-supported (Engzell et al., 2020). Understanding these factors is important to designing technologies that reduce rather than increase differences. While modes of parental engagement in mediating access to learning technologies has been extensively discussed in the design and human-computer interaction (HCI) literature (Yu et al., 2021), the pandemic demonstrated that shifting the focus from schools to caregivers may lead to greater inequality in learning. Particularly due to different levels of engagement and availability from parents or caregivers (Anzani et al., 2020), basic things such as setting up an account for a service can exclude children who cannot engage caregivers for permission (Keaton & Gilbert, 2020).

Thus designers need to consider the importance of multiple stakeholders in learning, including communication between teachers, students, parents and/or other stakeholders. One such effort in this direction has been made by ClassDojo, an application for primary education that aims to build links between the school and the home - mainly through updates provided through a variety of formats that are available to students, parents and teachers. The ambition could be extended to considering other stakeholders such as Scouts, charities and community groups that could not only extend children's learning to other settings, but also extend their support network.

Instead of treating children's environment as a distraction, designers could look for ways to account and reduce differences in support, allowing for connection and potential recreation of environments - for example through tasks that involve exploration of particular natural settings or through use of immersive technologies such as AR.

Changing responses to pervasive data processing

Systems adopted for children's remote education further assume an awareness of implications of data recording and sharing, which students - and indeed, many adults - often lack (von Struensee, 2021). Online communities and group chats, for instance, are often not monitored for the very young, and can risk exposing them to inappropriate content - for example profiles with 'child age' restrictions can be faced with extreme diet cultures or even self-harm content (eSafety Commissioner, 2019).

The need to minimise these risks is often interpreted as a need to restrict technology usage - for example there are guidelines for reframing technology for young learners, in particular by the American Academy of Paediatrics and the National Association for the Education of Young Children, that look at preventing children from being overexposed to digital devices and decrease potential technology addiction. Indeed, designers need to consider the implications of the technologies they design at every step of the process, such as when considering format, technology, interaction, context, remit, etc.

However, simply restricting usage is not the answer to minimise risks, as it doesn't increase understanding of what data is and how it can be used (for good or bad). In the HCI literature, there have been several discussions as to how parents and caregivers can take a role in mediating children's

interaction with technology (Yu et al., 2021), but these assume a level of parental involvement that children may lack. Instead, an attitude to supporting data literacy would look at supporting data literacy education, which, according to Ridsdale et al. (2015) includes (a) supporting diverse and creative learning approaches that make effective use of technology; (b) iterative learning of data-related issues with complementary skills integrated (such as in project-based learning); (c) an emphasis on the mechanics of data integration as well as concepts; and (d) increasing engagement with content by using real-world data.

Much of digital technologies' data processing takes place in the background of users' awareness, and while it is often taken for granted that adults are aware of these practices (when accepting terms and conditions) - even though many are not - the same assumptions become problematic when considering child users. With a general lack of transparency of data processes, assumptions become charged with concerns and often fears that platforms would constantly track users' data on behalf of businesses, potentially leaking, or selling to third parties (Pschetz et al., 2017), which is problematic for adults but could present increased risks to children.

Instead of parents and companies simply restricting children's access to technology, more transparent data processes, adequate ways to present terms of services or request consent (e.g., including different stakeholders and exploring other media beyond the legal contract), and extending the curricula to approach critical issues around data literacy could allow children to nurture a more positive attitude to data that could be transformational in their lives and for society as a whole.

Changing pace, exploring settings and increasing data awareness through AR

In our ongoing research, we are looking at ways to support cross-setting learning and informed data practices through apps that can help children understand environmental issues. We focus on issues of climate change as a way to connect children to a pressing issue, and to cultivate what Anna Tsing (2015) calls 'the art of noticing'. Although effects of changes in climate are manifested in many ways around us, noticing them requires stepping out of narratives of productivity and time saving to connect to the environment around us. Thus, we ask how children can engage with the changes that selected species (trees, insects, birds and mammals) experience as a result of climate heating. By engaging in, producing and contributing to recording data on biological phenomena like blooming dates in relation to climatic conditions (and therefore 'real-world' data), we invite children to engage in the multiple temporal patterns of nature and understand the delicate balance between species' temporalities, which allow for brief encounters through which species remake themselves and adapt to a changing environment.

Through the production of phenology records, children are invited to understand what a single data point represents in a larger context. Using data-capturing apps, children begin to understand how to produce records and how these can be interpreted in a larger context. While it has been shown that children have great ability to interpret climate change-related information (Eide & Kunelius, 2021); we aim to support them in translating a broad subject into tangible accounts, and to further allow them to see themselves as active participants of a database for the public good.

These approaches to pace and data practices are brought together through the use of AR - a real-time experience where one's physical world is enhanced with a layer of computer-generated information (Carmigniani et al, 2011). Since its inception in the late 1990s, AR has been extensively explored in education, with research stressing potentials and limitations alike. AR can have a key role in promoting retention, communication and engagement, by allowing children to apply learning across contexts and to deepen it through the addition of new layers, for example by making invisible aspects of an ecosystem such as pollution levels visible, or allowing inspection of every detail of a small insect.† AR has also been shown to increase confidence as it enables multisensory learning and allows students to learn by doing (Lu & Liu, 2015),

† A great example of this is the Smithsonian's AR app that allows the user to view replicas of popular exhibits in their own surroundings (Smithsonian, 2020).

and due to its ability to simulate real-life situations, it also has the ability to meaningfully engage the user (Fan et al., 2020). AR is also seen as a big industry that is likely to generate innovation, particularly in the education sector. UKRI (UK Research and Innovation) predicts that, by 2024, the immersive technologies industry will be worth £101 billion (Chitty, 2022), and in a 2020 survey by Perkins Coie and the XR Association, respondents named 'education' as the second most likely sector to adopt immersive technologies (Dick et al., 2021).

Nevertheless, the usage and benefits of the technologies are still dependent on teachers and students' technical skills, knowledge or familiarity with the software, and due to its mode of knowledge construction and reception, many of the benefits discussed in the context of learning - specifically, formal education - are difficult to measure because they cannot be compared with current curriculum targets. Furthermore, it presents challenges both in terms of education and data practices. Educational challenges include the potential of AR to: (a) distract students from learning aspects, if not properly used (Chiang et al, 2014); (b) be difficult to use by students and teachers alike, particularly without a well-designed interface or guidance (Munoz-Cristobal et al., 2014), (c) be content inflexible, which does not allow teachers to incorporate or connect it to their lessons (Fan et al., 2020), and (d) present challenges for inclusion of large groups (Furió et al., 2013). In fact, many educational institutes have not been keen on pursuing immersive technologies in their classroom due to available budget, existing ICT (information and communications technology) infrastructure (hardware, software and internet) and limited time to train teachers (Weerakanto, 2019).

In terms of data practices, AR apps are often part of technology ecosystems that derive value from gathering data from users, in ways that can present increased risks to children. For example, when investigating the implication of AR video games such as Pokémon, Das et al. (2017) found that the real-time location tracking functions increased threats of physical harm as well as posed risks to mental health through potential risk of addiction. Additionally, decisions to use AR in the classroom are mainly driven by the potential of these technologies to support teaching (McKnight et al., 2016), and include little reflection on how data will be processed as children interact with such systems. Design considerations, such as whether the AR experience will be consumed individually or collaboratively, in an informal environment, for example home, or in a formal environment such as school, and whether a parent or guardian will be present to supervise or provide context for the experience, could help address the problem of data infrastructure when designing education AR experiences.

Through our work we advocate that designers consider three factors in their initial design stage. First, consider 'how', by thinking of solutions to offer help and provide easy access to update content by teachers or parents and caregivers; previous researchers (Fan et al., 2020) noted a lack of flexibility with AR content as a disadvantage. Second, consider 'where', and specifically designing strategies to support collaborative learning, for example will the student be using the AR application at school with the teacher, superimposing it on to objects or sharing the device with a teacher or guardian to find information (Sytwu & Wang, 2016)? Third, consider 'who' - allow teachers and learners to explore or choose between various contexts such as learning style, groups, for example age, and learning contexts, such as individual or collaborative.

Conclusion

This essay presents the potential of cross-setting data-driven platforms to enhance children's learning, and discusses design considerations for these new ways of delivering education through AR. We draw attention to the need for:

- Integration of nuanced notions of pace and engagement to enrich learning experience and provide alternatives to exploitative models of technological development

- Experimentation with approaches to account for and reduce differences in learning support, particularly at home, connecting multiple

stakeholders and allowing exploration (and potential recreation) of real-world environments

- Experimentation with approaches to explain data processing, terms of services and acquisition of consent in a more meaningful, accessible, and age-appropriate manner while supporting collective decision-making concerning technology uses between parents and children

- Context and child-centric consideration and design of immersive technologies, such as AR, as a means for enriching children's learning experience.

We do not claim that cross-setting data-driven platforms could account for children's learning needs. Instead, we provide design considerations to inspire alternative approaches to EdTech design, combining understanding of formal subjects with informal explorations of the natural world that are underlined by critical data capture, and reinforced through AR explorations.

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