Digital Strategies for Supporting Strengths- and Interests-based Learning with Children with Autism

Cara Wilson, Margot Brereton, Bernd Ploderer, Laurianne Sitbon and Beth Saggers
Queensland University of Technology
Brisbane, Australia
+61 7 3138 8365
{cara.wilson, m.brereton, b.ploderer, laurianne.sitbon, b.saggers}@qut.edu.au

ABSTRACT
Technologies to support children with autism tend to use predefined content to enhance specific skills, such as verbal communication or emotion recognition. Few mobilise the child's own (often very specific) interests, strengths and capabilities. Digital technologies offer opportunities for children to personalise learning with their own content, following their own interests and enabling their self-expression. This project sought to engage children to record and express their own interests within their contexts of support – the home and the classroom. The vehicle for self-expression was an audio-visual calendaring app called MeCalendar. Implementation was kept open-ended to allow teachers to use it in ways that best fit with their existing embedded practices. In this paper we report on how the prototype has been appropriated in two classrooms by teachers in an autism-specific school setting with children aged 6 to 7. Our contribution is an understanding of how technologies for self-expression led to enhanced verbal communication, positive reinforcement through video modelling, engagement in class tasks and enhanced social interaction. Children appropriated the design in unimagined ways, leading them to self-scaffold and to catalyse their confidence in social interaction and self-expression. Teachers played an integral role in appropriating the design in the classroom, specifically through their in-depth knowledge of each child and their individual needs, strengths and interests.

CCS Concepts
•Human-centered computing → Accessibility technologies
•Human-centered computing → User centered design

Keywords
Child-Computer Interaction; Autism; Appropriation; Classroom

1. INTRODUCTION
Individuals with autism typically have challenges in a number of areas, often described as the presence of both impaired social communication and interaction, as well as restricted, repetitive patterns of behaviours, interests or activities [1]. However, and as highlighted in the recently revised Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition (DSM-5[1]), children on the spectrum are an extremely heterogeneous group and express these criteria in very different, eclectic ways [29]. It is important to note that there is much debate around the terminology used to describe autism. Kenny et al. [27] discuss that there continues to be divided preference on whether person-first language (i.e. "a person with autism") or identity-first language (i.e. "an autistic person") should be used. The term Autism Spectrum Disorder (ASD) has been criticised for being deficit-focussed, i.e. centring on the disabilities, not the abilities, of people on the spectrum and for being so inclusive as to trivialise the issues of some forms of autism [27]. Thus, we see that the debate here is complex. Here we use the person-centred term "child with autism" as it is most commonly used in the community of our study participants, where children are still developing their identities.

While we are witnessing both an increase in technologies to support children with autism, and the inclusion of developmentally diverse children in the design process [8], technology to support children with autism is often limited to predefined content to enhance particular skills. It is common to see scripted scenarios to teach topics such as emotion recognition [26], social skills for specific situations [22, 23], or specific behaviours [39]. While such technologies have demonstrated efficacy, in our research we sought to approach learning from a different perspective, asking how we can begin by building on the children's own interests, competences and motivations, expressed through their daily activities.

In summary, we investigated how to empower children with autism by supporting them to document and communicate their own interests and competencies using technology. We examined how both teachers and children appropriated and used the technology. We also observed other classroom support mechanisms employed by teachers and how they integrated the new technology into their practices. We present several considerations when designing supportive technology for and with children with autism.

The study utilised an open-ended implementation of our prototype, an audio-visual calendaring app named MeCalendar [10], which enabled children and their teachers and caregivers to document activities of interest to them on a daily basis. We aimed to explore how both children and teachers appropriated this technology in the classroom and further, to understand how this supported children's interests and competencies.

Our contribution is an understanding of how children's communication and engagement improves when they are supported to communicate about their own interests through flexible design prototypes. Children appropriated the design in unimagined ways, leading them to self-scaffold and to catalyse

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their confidence in communicating. Teachers also played an integral role in appropriating the design in the classroom, specifically through their in-depth knowledge of each child and their needs.

2. RELATED WORK

2.1 Autism and Technology

Research at the intersection of autism and HCI has led to increasing development of technologies which aim to support various aspects of autism [4]. Technologies designed to support children with autism have included; interactive environments to support movement and gesture [28], mobile technologies to encourage play and social interaction [24, 5] and learning through touch-based games [6]. These technologies aim to enhance self-expression and some encourage activities children enjoy in order to enhance specific abilities or skills [22, 23].

Assistive Technology has emerged as the dominant design approach when working with developmentally diverse groups, the underlying goal being to create technology that increases, maintains, or improves functional capabilities of individuals with disabilities [30]. However, in line with Frauenberger et al. [19], we believe it may be time to think *beyond assistance and intervention,* in designing with and for those with autism, and towards a more holistic approach which supports individuals towards self-expression and self-empowerment. There is increasing discussion on the importance of ability-based design, noting that interactive technologies which adapt to users' abilities, different user skills, and changing user contexts can support ability-based design [41]. Further, the Autism Co-operative Research Centre's recent Australian Educational Needs Analysis report [33] found that technology was reported to be an effective support for learning in areas such as writing, communication needs, transition needs and socio-emotional needs, with parents and teachers reporting the use of a wide range of technological supports in both school and at home contexts. It was found that iPads were one of the most common technologies used in these contexts (ibid). In terms of classroom-specific technologies**,** Hourcade et al. [22] highlight, there are many commercial apps available which claim to support children with autism in the classroom, but few are empirically verified. Examples of those which are backed by research include Hirano et al. [21], who developed a digital scheduling tool, vSked, for use by the teacher in classroom settings in supporting visual scheduling. Other studies have looked into the use of visual supports [16] and motion-based activities [6] to engage students with autism in the classroom. Hourcade et al [22, 23] developed a suite of flexible apps which aimed to encourage children with autism to engage in social interactions while undertaking activities that they enjoy. Their goal here was to encourage interaction by associating it with a pleasurable activity, so that the interaction in turn became desirable. The tools were designed open-endedly, to ensure the children felt free to express themselves.

The aforementioned technologies notwithstanding, few technologies explicitly aim to foster the individual child's interests and aspirations, and find ways to help communicate these central human desires to proxies and communities. Winter-Messiers [40] discusses the importance of special interest areas (SIAs) in the enhancement of young people with autism's socia communication, emotional, sensory and fine motor skills, noting the critical need for teachers to understand and value the special interests of these students. By integrating SIAs into academic work, teachers may see the generalisation of these motivations into classwork activities, providing a forum for children to demonstrate their true abilities. This work led to the development of a strengths-based model of SIAs, which proposes that 'deficits' traditionally associated with autism, such as language, body language, social communication, emotions, sensory, and fine motor skills, consistently *diminished* when children with autism engaged with their own special interests in education contexts. As Winter-Messiers [40, p.149] succinctly puts forward: "We must see SIAs for the gold mine they are in helping our students progress toward their academic, social, emotional, communication, and behavioural goals." As Hourcade [23] points out, children's uses of technologies are as diverse as the children themselves, thus, the need for personalisation and individual focus is clear. We would add that design which provides scope for the expression and sharing of these diverse interests acknowledges the concept of children as experts in their own interests. Thus, we see the need for a tool which is flexible, both in its design and in its implementation, and which supports children's interests.

2.2 Appropriation and Open-Ended Design

Dourish [12, p.465] describes appropriation as "the process by which people adopt and adapt technologies, fitting them into their working practices". As Brereton et al. [10] note, successful appropriation depends on the ability for technologies to fit with the users' skills, values and goals. Indeed, some argue that it is part of the design process itself [11]. This leads us to the concept of scaffolding, i.e. the support given to learners to enable them to achieve objectives they would not have achieved without support [2, 4]. This is a common approach in autism education, often used to teach social behaviours [34] by providing tiers of support from core to targeted to intensive. We propose this may be extended to appropriation of digital tools with children with autism. Indeed, Kellogg and Erickson [25, p.31], in their work on appropriation and social scaffolding, suggest that, for users to appropriate technology, they must "both understand its capabilities and have scaffolding mechanisms for collectively discovering, structuring, iterating, and promulgating practices that enable the technology to become a... 'resource'". These perspectives are especially important in autism-specific contexts in which social communication and interaction is often challenging and scaffolding on the part of teachers may be required in order to enable appropriation.

We propose that open-ended technologies which afford customisation and appropriation [3] can help us move beyond assistance and intervention [19] to allow children with autism to record, express and share their interests and competencies, on a personal level. Work on autism and virtual reality by Ringland et al. [31] highlights that accessibility can be fostered through appropriation of "mainstream" or "mundane" technologies, in order to enhance user experience, emphasising the importance of flexible designs which can be customised by the user in accordance with their own interests and preferences. This allows users to more freely express their identities. Their work centres on the importance of these "DIY approaches", that is designing technologies which can be easily adopted and adapted (i.e. appropriated) by the child with autism to foster certain skills or competencies. Here, our work is similar in its intentions, but investigates appropriation in a classroom context as opposed to a virtual reality context. Sengers and Gaver [35] promote the value of staying open to design interpretation through the support of multiple meanings in design and evaluation. Further, Lucy Suchman [36] identifies the often-common incidence of

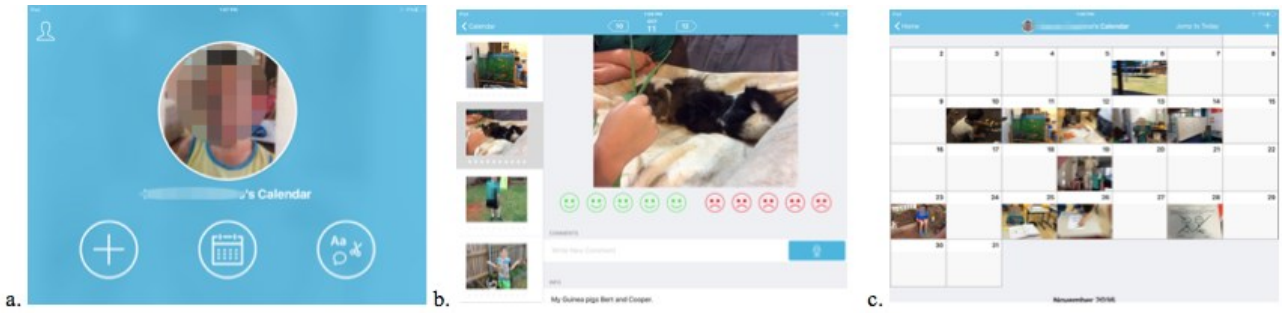

Figure 1. Screenshots from MeCalendar depicting (a) the Homepage which allows the user to choose between making a new entry, going directly to the calendar, or reviewing their tagged skills, (b) an entry by one child showing his pets with the caption 'My Guinea Pigs Bert and Cooper', and (c) the calendar view depicting all entries in a monthly layout.

discrepancy between designer assumptions and user interpretations of design in real-world situations. Suchman's concept is echoed by Frauenberger and colleagues, who discuss that "deliberately open" design briefs for supportive technologies allow for designs which are "un-imaginable to the neuro-typical adult designers" [17, p. 130]. This is particularly relevant in relation to those with developmental differences as users often appropriate technology "in ways designers do not envision, to support needs that may not have been fully understood or anticipated" [31, p33].

2.3 Relevant theories

Relevant theories from the fields of Psychology and Sociology support the notion that children's interests and social contexts merit attention. Self-Determination Theory [32] is primarily concerned with the potential of social contexts to provide experiences that satisfy people's universal needs for feelings of competence (a need for challenge and feelings of effectiveness), autonomy (a sense of willingness and volition) and relatedness (social connection with others). Satisfaction of these three needs has been shown to yield enhanced self-motivation and wellbeing.

Turning to Speech and Language therapy, we highlight the child-led approaches employed by professionals in this area. Greenspan et al. [20], for example, emphasise the importance of 'floor-time interactions' with a 'child with Sspecial needs', an approach which encourages parents to get down on the floor with their child and interact and play, following the child's interests and motivations. The Floor-Time Approach describes its four goals as the encouragement of; attention and intimacy, two-way communication, logical thought, and the expression and use of feelings and ideas. As Greenspan et al. [20, p123] highlight "through interactions, you can mobilise your child's emotions in the service of his learning" and suggest doing so through following her interests and motivations. The Hanen Centre's 'More Than Words' (MTW) approach [37] is a socio-interactionalist program developed for the parents of children with autism who also have speech and language delays. The key here is that adults can enhance the child's social participation in interaction by interpreting and responding to the child's communicative attempts as if they were intentional. This means following the child's lead to create communicative interactions around the child's interests or focus of attention. We consider these approaches and ask; how can we mobilise and support this learning through digital strategies? How can we extend these approaches to the digital sphere? We know of few studies which investigate how to extend these theories from other disciplines into a digital context. We ask: how do we take approaches beyond therapy settings and intensive one-to-one parent-child activities, to enable the child to bring their personal explorations to a shared place? Theoretically, therefore, we aim to build on child-led approaches and competency-based approaches in the digital sphere, embedding these into daily living through digital means and to answer the question: how do we use digital support for real world interactions?

3. STUDY DESIGN

The aim of this study was to explore how children with autism and their teachers appropriate the open-ended design of supportive technologies for use in classroom settings. To achieve this aim, we employed the use of an existing concrete prototype, previously developed by the research team. MeCalendar is an audio-visual calendar app for the iPad, which supports children to communicate daily personal activities through photos and videos [10]. The prototype is set up in a typical calendar layout (Fig. 1c). Children, teachers and parents are encouraged to click on the date, and select between uploading a photo or video from the device's gallery, or taking a new photo or video (Fig. 1a). These can then be annotated in the notes section and written information or audio clips about the photo or video can be added (Fig. 1b). The entry is then saved to the chosen day and can be shared between home, school, and other settings. MeCalendar was developed prior to the present study and the full details of the design evolution can be found in work by Brereton et al. [10]. The design concept grew from co-design work with teachers and parents at a special needs school. The idea of a calendar structure emerged to help children develop a sense of time as well as planning skills. The researchers' and parents' experiences of using tablet computers such as the iPad also contributed to the design concept and this ultimately led to the development of the present concrete prototype, MeCalendar.

The research draws upon best practices from established methods for engaging participants, such as Participatory Design (PD) [15] and Action Research [13], and engages with these methods in ways appropriate to the participants. We partnered with an autism-specific primary school in Brisbane, Australia, working closely with two classes of six children, aged 6-7 years old, and two class teachers, over 10 weeks. The children had varying levels of ability and verbal skills, however, we do not find it pertinent to expound these here, as this project is about supporting individual strengths, not dwelling on individual "deficits". Children were each provided with an iPad Mini 2, on which we disabled Internet access, at the teachers' request, thus the iPads were used solely for MeCalendar. Teachers were asked to use the app in any way they wished in the classroom and had complete freedom over its implementation. Design implementation was kept open-ended to allow teachers to use it in ways that best fit with their existing

embedded practices and close understanding of each child. Insights into the appropriation of MeCalendar were gathered through diary data, participant observation, and interviews. Teachers were asked to reflect on their use of MeCalendar in a diary or Teacher Reflective Log. In total we spent 5 days in the classroom. Observations were recorded as field notes. Additionally, we took photos and video-recorded over 20 hours of classroom interactions involving children and teachers interacting with MeCalendar. Finally, we conducted interviews with each teacher before, during and after the school term to discuss their experiences with MeCalendar and to reflect on our observations of MeCalendar use.

Data analysis followed the process of thematic analysis [9], based on a variety of rich data: diary entries from teachers, field notes from our observations of use in classroom, transcripts from interviews with teachers, and video, audio, photo-visual and text data collected from the children's iPads. We sought to interpret the data and define the themes from the perspectives of both the teachers as well as the perspectives of the children to show whether and how the design might have empowered them to support their ways of teaching, learning, and interest-based engagement. Hence, the findings contain two sections to report on appropriation by teachers and by children. All direct quotes are from teacher interviews, where 'TA' represents Teacher A, and 'TB', Teacher B. The names of the children have been changed in line with ethical consent. While teacher opinions on the technology were explicitly gathered through interviews, understandably, explicit quotes from minimally-verbal children are not often obtained. Thus, we base our findings from the 'child-led appropriation' perspective on participant observations of the children and their use of the tool over several observation sessions. We hope to address this imbalance in future work which focuses on supporting the design contributions of minimally-verbal children with autism.

4. FINDINGS

We found that appropriation in the classroom was two-fold, comprising both teacher-led (explicit) and child-led (observed) appropriation. While teacher-led appropriation was predominantly based on learning and behavioural outcomes, child-led appropriation was based predominantly on their own interests.

Each teacher implemented the prototype in different ways, drawing attention to the nuanced and variable meta-practices at play in each teacher's classroom. This was then either built on by children and appropriated as a learning activity, or children appropriated the technology in independent ways. With child-led appropriation, the importance of the child's own interests became apparent, as they used the prototype to support these, as well as learning activities, as described below. We call this independent appropriation by children "self-scaffolding" (e.g. Bickhard, 2013) and will elaborate in the discussion section.

4.1 Teacher-led Appropriation

Each teacher had different perspectives on how the calendar might be best implemented and used in their classroom, best defined as *structured* vs. *free-use*. For example, TA used it in a very systematised way, specifically appropriating it for use during language and handwriting tasks at set times each day and providing a rotational one-to-one session with each child (structured). TB used it more broadly (free-use), as a motivational tool and as a support for modelling behaviours, noting: "*So yes, mine sounds a lot more chaotic than hers [laughs]. I'd say ours is very warm, causal, informal kind of thing and yeah, I use it a lot for motivation"* [TB].

Despite these differences, however, both teachers had some similar implementation techniques, the most prominent being that each used the tool as a support for a weekly 'Show and Share' session, whereby children would be invited to the front of the class to discuss a photo or video they had taken in MeCalendar, either at home, at school, or elsewhere. This suggests that the tool lends itself to particular forms of common appropriation. The differences in appropriation show that the tool was flexible, as well as the importance of an open-ended approach to implementation. Through this approach, we were able to see the vast array of activities the teachers imagined for the tool as well as how they integrated the tool into existing practices, strategies and expertise.

4.1.1 Verbal Ability

Teachers reported that some non-verbal students had begun to talk in class, using spontaneous language to describe their MeCalendar photos and videos. Differences in verbal ability, such as late development of speech, are common in autism, and many children with autism present limited or no verbal abilities, and may be described as *minimally-verbal* [38]. As previously discussed, the teachers in our study both appropriated MeCalendar as a 'Show and Share' support tool. In this context, children were asked to come to the front of the class and discuss a photo or video they had taken in MeCalendar, either at home, at school, or elsewhere. The social expectation and attention of the full class could be seen as very daunting for the child, and the teacher used the exercise to encourage confidence in speech and communication. Despite the difficulty of the task, teachers reported that using the prototype as a visual prompt provided great support for the children. *"Mikey has no spontaneous, or had no spontaneous, language. He really struggled to make eye contact and even just, you know, to stand in front of the group. Now, he's willing to get up there and he's spontaneously using language"* [TA].

In this case, the teacher reported that there was not a lot of language, perhaps a few key words, such as "brother" or "dog" but that this in itself was a great increase in the verbal skills of the child. In children who were already verbal, the teachers found that the prototype helped encourage more focussed and descriptive language, as well as functional language*: "I go "what's this one" and he's like "oh a swimming pool, oh yes I went there for a swim with my brother in the back yard and..." so you know, huge stories, very different, very different!"* [TB].

Although not specifically intended as a visual prompt, we found that the calendar was appropriated as such, perhaps due to the personal nature of the image (Fig.3): *"My non-verbal kids are talking. They are so motivated having their picture in front of them, on their screen. We've had lots of Halloween pictures and so that's inspired conversations, so they're really motivating."* [TA].

4.1.2 Classwork

We found that teachers naturally used the app to support class tasks, with particular focus on using it towards achievement of the child's IEP (Individualised Education Programme) goals. These goals are individual, curriculum-based goals set for each child, often relating to behavioural skills which enable classwork, such as "I will sit at my desk when I am asked". Enhancing writing skills was of particular interest to TA and thus the prototype was appropriated for use in handwriting tasks. Due to common fine motor difficulties in autism, handwriting is often not a well-liked

activity, requiring concentration and precision. Indeed, children with autism can often show resistance to such exercises in the classroom. *"Handwriting is a particular issue in this classroom but I have no resistance from any of them now*" [TA].

Teacher A's approach was to implement a routine for handwriting around MeCalendar. Children would be asked to take a photo at home which they could then discuss with the class during their Show and Share slot. The next day, the teacher initiated a one-to-one activity with the child whereby they would think of vocabulary related to their photo and then create sentences with the selected words. She found that even the children who usually showed resistance to handwriting were "willingly" attempting it: *"His handwriting is one of his IEP goals, and he hated handwriting, um, and would show all sorts of resistant behaviours, drop to the floor, cry, run away, even become aggressive with us. This was last week's [shows an example worksheet]. He's now willingly talking about his photo and then when I ask him to write it down, he's willingly writing it down, which is just great."* [TA]

One child preferred to have his MeCalendar beside him on the desk during handwriting tasks so that he could carefully copy words. TA explained why she thought this strategy works: "*It's because it's his own calendar, and the words he's writing match his calendar and his photos, so they mean more to him"* [TA].

4.1.3 Socialisation

We found that, through teachers' strategies and expertise, the app was implemented in such a way that socialisation was enhanced, both in broad social communication areas such as child-to-child interaction and whole class bonding, as well as in more specific areas such as turn taking, eye contact and body language. We use the broad term "social skills" here, referring to everything from body language, to verbal communication, to listening, to eye contact, to turn-taking. For example, for one child, Cody, standing in front of the class and communicating about their calendar was very daunting, however, through using the calendar as a visual prompt: "*The non-verbal children, even just to get them to stand up, like one of them yesterday for the first time stood facing the group [for Show and Share] which has never happened before... But he's actually turning now to face them [his classmates], he still can't give direct eye-contact, but his body language is indicating that he's open to questions, so that's huge for him."* [TA].

For another child, the teacher tailored her approach in order to address his difficulty with staying on-topic in conversations and providing an "in" in terms of something to pin conversations on that is interesting to him while also providing the teacher with the learning outcomes she wishes to pursue with the child*: "It's given us something to talk about... it has opened up the lines of communication. So, for Daniel, there's more joint communication, on topic, about something, rather than him rabbiting on about a story that he's seen on TV or something. So, there's definitely increased functional communication."* [TB].

Further, in terms of child-to-child interaction, the teachers felt that using the prototype was creating a "warmth" in the classroom, enabling the children to get to know each other better through their Show and Share sessions*: "Yeah, it's knocking down a couple of little boundaries! Actually I think we're getting to know each other better. I feel as though we're, you know, getting a bit closer. I feel as though we're bonding [laughs]... We're sharing a lot "oh you did that on the weekend". So it's definitely bringing a positive feeling, like a warmth. It is, it's creating a little warm feeling."* [TB]

4.1.4 Behaviour and Modelling

Teacher B teacher organically used MeCalendar as a video modelling tool. The teacher took photos and videos of the children while they were exhibiting a positive behaviour, such as sitting at their desk and completing their classwork (Fig. 2). She notes: *"I do little interviews with the kids while they're doing their work. Some kids get particularly motivated if it's a hard task like writing or something or other and I say "Oh shall I get a picture of you and you can show it to mummy and daddy?" when they're sitting down and competing their work."* [TB].

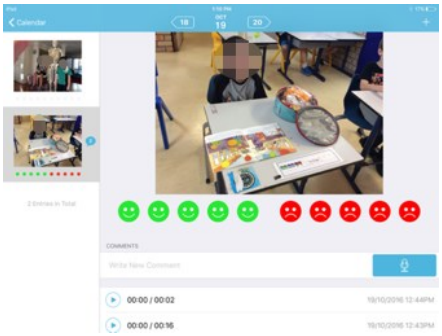

Figure 2. An example of modelling - a child working at his desk

She discusses another child: *"Daniel, I've recorded him for five or six minutes straight. I stood there with the video going while he did a maths sheet. He's one to give up very quickly very easily - so it was six minutes well spent. And there he his, diligently working away and I'm recording comments going "Well done!"* [TB].

4.1.5 Calendar Format

The teachers provided feedback on the calendar format of the app and why this particular structure seems to have been useful. TA noted: *"Using their interests is so crucial and I think that, putting it in that calendar format gives them that sense of time too. Because a lot of our students haven't got that concept of before and after. But through this, Robin was able to say to me "I went camping a long time ago" because he was able to see on his calendar that we were now in November and he'd been camping in October. So he's starting to put his own time frames to things. He's now putting the pieces together himself which is ten times more important than anything I could teach him in class*." [TA].

When asked if any form of photos or videos might provide the same support, teachers responded that they valued the structure afforded by the calendar layout, and this also allowed for the teaching of calendaring and time concepts. TA noted that the calendar format allowed the children to track their progress and, further, to remind themselves that they had successfully shared information with the class previously, thus encouraging confidence in sharing again: *"I don't think it would have as much meaning without the calendar format. For my particular students who are really engaging with it, I think because they're able to personally track themselves. And, just by putting up the calendar on the whiteboard Colby can see that he had success last week on Wednesday by telling us about his bike riding, that then gives him that little bit more confidence and motivation to talk again. And he does, he gets up there and he puts it on the screen and he reflects on it and you can see his little chest puff out! So it's given*

them a sense of security because they can see, "Well I've already done this, I know what I'm doing."" [TA].

4.1.6 Using Interests

TA reflected on why encouraging the children's interests through the app was beneficial in her class: *"Instead of me trying to find the stimulus that interests them, and me having to try and direct their learning, they are doing it for me [laughs]. They are giving me the stimulus, they're giving me the feedback, so it's very easy for me just to run with it, which I'm just loving, absolutely loving. Um, because we're not seeing any avoidance, because these are their interests. So they're both sitting at their desks and working away, they can access MeCalendar independently, they can access their photos independently, and because its got the multiple photos for each day they're loving having the flexibility of choosing which one."* TA noted about another child, Ryan: *"He loves presenting to the rest of the class. But only if it's a photo, a personal photo. If I were to give him something else to provide a description of, he wouldn't be as willing to do it, we'd have to do a lot of prompting."*

4.2 Child-led Appropriation

Beyond teachers' strategies for implementation, the children had their own ideas and strategies for appropriation of the prototype. To that end, we have structured the following section with headings which we feel reflect the child's perspective and reflect the interest which is driving their appropriation. This child-centred language arose as part of the analytic method, whereby we attempted to approach the data from the child's perspective.

4.2.1 Breaking Routine / I want to try something new

Children with autism commonly need routine and structure however, flexibility is a crucial part of the curriculum. TA had a daily classroom activity known as "Change of the Day", in which the children had to do something differently from how it was usually done, while she supported them in the change. Our findings suggest that appropriating a technology to communicate about their interests can scaffold children to help them "break" a routine. We see this as a form of self-scaffolding using technology. The willingness of children to break their own routine in order to stand at the front of the class and communicate was still surprising to teachers. This also suggests that this routine rigidity may not be as important to the child if they are confident in discussing something they are interested in or have a deep knowledge of e.g. their pet cat.

One child, Mikey, who the teacher notes is usually extremely rigid in his routine, was adamant that he would have a turn at Show and Share, despite the fact that it wasn't his usual day to do so. The same child is also very limited verbally and so his confidence in standing up and talking to the class (Fig. 3) was extremely "pleasing and emotional" for TA: **"***When you were here last time, you remember he actually insisted on having a Show and Share, even though it's not his day, which, for Mikey who is such a routine, regimented, child, he knows, Wednesday is his day to do Show and Share, for him to break his own routine is phenomenal"*

4.2.2 Unprompted handwriting / I want to write

Despite usually showing high levels of resistance to writing tasks e.g. running away or crying, Matthew spontaneously began to write a list by copying words from MeCalendar. In a one-to-one session, the teacher asked the child to think of words related to his photo on MeCalendar, in this case a photo of a pumpkin being carved for Halloween*: "He was completely inspired to copy and trace the words and then he drew his own picture of a pumpkin, completely unprompted and then he wrote his name, all of which he doesn't usually do. So it's all becoming very spontaneous"* [TB]. This uncharacteristic action suggests that perhaps the child did have an inherent want to be able to write, but needed a support in his attempts to do so.

Figure 3. Mikey breaking his routine in order to take part in Show and Share

4.2.3 Modifying Class Tasks / I want to learn this differently

Children used the prototype to approach classroom learning in adapted ways. Children's confidence in using the tool in new ways may suggest that the tool helps them express and explore their own interests with confidence. In this context, the children were gathered on the floor at the front of the classroom, looking at the interactive whiteboard on which the teacher was discussing the day, date, month, year, and weather. After going round each child and asking them to tell her one of the above components of the calendar, she asked the children to then write down the information from the whiteboard on a worksheet. During our observation session, one of the children decided they would prefer to take a photo of the whiteboard using MeCalendar, then typing up the requested information in the comments section below the photo. He wrote down all the requested information – day, date, month, year, and weather – and then continued to write more about the day e.g. "*It is very sunny. I am very happy*". Thus, we see that, while some activities may be difficult for the child e.g. handwriting, there are other forms of support to allow them to pursue their creativity, without having to concentrate on a fine motor task.

4.2.4 Positive Reinforcement / I'm proud of myself

Children were observed by the teachers and the research team replaying videos and audio clips taken by the teacher of them exhibiting good behaviour in class. The teachers identified this as an act of positive reinforcement through watching themselves successfully completing a task: *"I noticed that on all the ones I've videoed of him doing his work, he's pressing the play button so he can listen to it himself and, you know, he's sitting there smiling, he's engaged [laughs]. So, yeah, that's all very good... He was independently checking that out"* [TB].

Teacher A also found that children enjoyed sharing these positive comments with friends*: "And at the end, when they've finished I'll say "Do you want to get a picture of it?" and they'll go and get their iPads and take a picture, because they're very proud of their work too". And if it's been particularly good I'll press the microphone and say "Wow Matthew you've done an awesome job!" Then I press stop and they're so pleased, playing it again and showing it to their friend with my voice over the top, because it's so exciting*."

4.2.5 Fun / I want to play

Perhaps an obvious way for children to appropriate a new technology is through fun and play. One child, Tyler, showed us a

photo of himself in his martial arts uniform. In the classroom, there are rotations of activities, and one such rotation involved time for each child to use MeCalendar in whatever way they would like. This unstructured, free-use approach allowed us to observe one child replaying a video of himself and his dad singing. *"For him, the most motivating ones are of himself singing"* [TB].

Other children used the calendar to store and review their hobbies and interests, which included; gnomes, Aikido, playing the Wii, fire engines, pets, scootering, trains, drawing, swimming and hot water systems. The children took photos and videos in MeCalendar of the things they found fun and annotated these e.g. "My toys I love the best". The teachers liked that the children had appropriated the technology in this way as it allowed for unprompted writing and speaking practice, when annotating or adding audio clips.

4.2.6 Sharing /I want to share what I like and make friends

Children appropriated the technology as a tool to help them communicate and share with each other, fostering child-to-child interaction in the classroom. Interaction between children with autism can be nuanced, as the child's understanding of the social world around them can be limited or overwhelming [34]. In this example, two of the children leveraged the prototype as a social interaction tool, using it to show each other photos of interest to them, as well as to take photos of one another on their MeCalendars. This enhanced and scaffolded their friendship and their understanding of each others' lives outside of school. TB comments: *"I know that Kyle and Bobby like sharing with each other, definitely, like they've got a nice little friendship now and they've definitely shared with each other without me asking them... It's technology, so they love it. Now they are taking photos of each other and go home and show their parents "this is my friend at school"*" [TB].

5. DISCUSSION

The findings indicate that, given an open-ended implementation approach, teachers gravitate towards appropriating technology in classrooms in ways which support children in the pursuit of their verbal, social and behavioural goals, as well as the classwork goals which support these. Teachers were found to scaffold educational and social activities in order to support each child's individual interests or competencies, tailoring them specifically through their in-depth knowledge of each child. We call this *teacher-led appropriation*. Secondly, we found that the way in which children with autism appropriate design in the classroom centred around the enhancement or communication of their own interests. Children were found to engage in *self-scaffolding* activities, whereby they used the MeCalendar prototype to support their personal interests (i.e. to verbally express or to visually represent interests), effectively integrating it into their daily lives. We call this *child-led appropriation.* This work highlights the need for design which supports child interests and competencies, the effectiveness of open-ended design implementation, and the role of self-scaffolding in the appropriation of a technology by children with autism. The findings can be categorised into three main elements; interest-focussed approach, scaffolding structures, and classroom integration.

5.1 Interest-focussed Approach

The interest-focussed approach provided by the app enabled teachers to engage the children in classroom activities and child participants to reflect, share, and strengthen their interests. Teachers commented that the use of interests was crucial in engaging the children on a deeper, more personal and holistic level with their classwork and broader skills work, supported by work in special education research [33, 40]. That teachers found they could step back and let the children direct their own learning through use of their own stimuli suggests appropriation on a meta level. In terms of extending the child-led approaches from Speech and Language disciplines [20, 37], we see a strengthening of child-led approaches to learning through children using their own personally relevant stimuli. The calendar design was perceived to mobilise confidence within the children, perhaps due to an enhanced sense of competence when talking about a topic they know well, or an item or activity they love, such as fire engines or gnomes. We suggest that the children feel competent because they can express their interests, and because they are encouraged and supported by teachers to express these. Perhaps the prototype has acted as a catalyst, tapping into the child's genuine interests and providing a vehicle through which to convey these to others. This, in turn, is supported by teacher expertise, as they appropriate the technology and shape the child interests towards the enhancement of skills and competencies. The idea of mobilising confidence within children with autism certainly fits with the theoretical lens of Self-Determination Theory. We suggest that the calendar satisfies three components; competence (I am able to use this tool / I am an expert on my own interests), autonomy (I can choose what I want to include in my calendar) and relatedness (I can communicate my interests to others through MeCalendar/ People understand me). Ryan and Deci [32] propose these are essential components of self-motivation and mental wellbeing.

5.2 Scaffolding Structures

The prototype provided scaffolding structures for both teachers and children. These arose in the form of four distinct but interrelated types of scaffolding structure; teaching structures, temporal structures, audio-visual structures, and child-led self-scaffolding structures.

Teaching structures influenced both teachers' inherent understanding of each child (social) and the underlying curricula to which their classroom activities are pinned (educational). It would perhaps be difficult to support children's interests and indeed for children to appropriate classroom technology without teachers' expert strategies and knowledge. Thus we see the teachers' expertise is crucial to the way in which the technologies are appropriated, in line with literature from the field of education and Assistive Technology [16]. Teachers use their expertise to provide a broad scaffold: children construct their own self-scaffolding within this.

Teachers appropriated the calendar layout as an opportunity to teach temporal aspects. The prototype was found to provide temporal structure through its calendar format, leading to holistic learning of time and date concepts for children who may be described as 'higher-functioning', as well as broader sequencing concepts, such as "tomorrow" and "yesterday", for children who may be described as 'lower-functioning'. In line with literature which suggests that structure and routine is important in autism support [34], we found that the structured format of the calendar layout provided children and teachers alike with referential boundaries in which to create, organise and retrieve audio-visual content. This was of particular use for children for whom days, dates and time are very abstract concepts.

The audio-visual structure provided by the prototype enabled several instances of prompting for interaction and expression. Often, photos were used as visual prompts through which to

engage the children in discussion or to make abstract concepts concrete. Audio clips of teacher's praise were replayed by the children in acts of positive reinforcement, feeding into the larger IEP goals of e.g. completing classwork or sitting at one's own desk. While we recognise such functionalities may already be provided by tablets (through e.g. camera function, video camera function, and voice note function), teachers commented that it was the integration of photos, videos and text into an accessible tool which allowed such activities as self-tracking, independent search and self-reassurance of previously completed tasks. In turn, this allowed for ease of use and access, for teachers and children alike. We found that the integration of the audio-visual element into a calendar structure provided children with an understanding of concepts which teachers were keen to teach. Through leveraging the children's own interests, the calendar became less about explicitly teaching sequencing of time and days, and more about the 'when' of everyday life. Through this approach, children began to learn about sequencing of time and days more holistically.

The ways in which the technology was appropriated as child-led self-scaffolding structures were of particular interest as they were unexpected and yet frequent. Teachers commented on how the children broke routine, adapted learning activities and extended social interaction beyond their usual scope. This was surprising for the teachers and led to new insights into how the prototype can support children's latent needs. For example, when Mikey became upset that it wasn't his day to present his Show and Share, and then insisted on presenting on his topic of interest – videos of himself singing. On one level, this was an example of a child standing up in front of his class and explicitly conveying an interest to the group. On another, deeper level, he could be considered to have self-scaffolded a learning opportunity for himself, whereby the support environment surrounding him had allowed him to be opportunistic, supported by his photos and videos in MeCalendar. If we take scaffolding to mean the support given to learners to enable them to achieve objectives they would not have achieved without support [2, 4], we see that in this example, the child is providing the support to himself, using the technology as a prompt. This could be described as an act of self-scaffolding, whereby children use their own interests, and supporting media, to scaffold their interactions, rather than using pre-defined scaffolds provided by others. As one teacher remarked, the children were able to provide their own stimulus, and thus direct their own learning. The above observations about scaffolding resonate with related work. Frauenberger [18] discusses how a technology can also be a catalyst which scaffolds human interaction which surrounds it. In our case, the technology provided a visual prompt and memory tool, armed with which children could feel confident about the interests they were trying to express. Frauenberger [18] discusses that, despite having some pre-defined notions as to what a technology might achieve, it can also act as a catalyst for the scaffolding of other outcomes. Importantly, he notes that our designs can scaffold interactions. They can "mediate and empower" [18, p.57]. He also suggests that when design is appropriated in this way, the outcome, in this case expression of interests and competencies, can become meaningfully situated and implicit as opposed to instructional. Thus, we suggest that technology which can be appropriated by children for self-scaffolding and supported by teachers' expert knowledge, may lead to growth in confidence in the expression of interests and competencies, which in turn are used by teachers to support learning.

5.3 Classroom Integration

Teachers employ a great number of strategies in order to elicit and enhance social skills in children with autism. Noticeably, both teachers employed a different integration strategy; one structured, one free-use. MeCalendar seemed to provide a broad scope for support, allowing the teacher to use it for particular social aspects for particular children, and each in her own style. By all accounts and purposes, this app is very simple in its conception and design: a calendar layout which allows insertion of photos, videos and comments for each day. The prototype was also physically accessible, meaning the children could easily carry it in their schoolbags between home and school, use it around school and when doing other activities too, encouraging everyday, integrated use.

The observations about appropriation in the classroom extend related work in several ways. Firstly, while previous work explored the interests of children with autism through playful interactivity in virtual worlds [31], our research highlights that these interests can also be successfully integrated with more formal learning activities in classroom settings. Similar to Hourcade et al. [22, 23], we focussed on enhancing skills through interactive tablet applications and deliberately open-ended work. In contrast to their design, however, MeCalendar extended work to the specific context of children with autism and we left it to the teachers and children to adapt and adopt the design according to their needs and interests, without the intention of enhancing one specific ability.

It is important to note the limitations of this research and how it can be improved. One aspect of the design implementation which requires further work is parental participation. Despite indicating interest and engagement at the beginning of the project, parental participation was low throughout the study. In terms of limitations of the tool itself, for example, we found that children at times found the buttons too small to be accurately pressed and some became frustrated at inadvertently pressing the incorrect button (e.g. 'Home' instead of 'Add Photo'). Addressing this is of particular importance as some child participants had fine motor skill challenges which led to challenges in dexterity. Another challenge described by teachers was the number of steps between taking a photo or video and having it successfully added to the calendar. Having to confirm the use of the photo two separate screens was problematic (currently users must click 'Use Photo' on in the entry window, and then again click 'Save' once they have entered a title for the entry). This is supported by observational data which showed that children often became impatient with this process, thus, a more streamlined media entry process will be developed. Teachers also provided design feedback regarding opportunities to extend the app, for example extending the current function to add smiley faces to any entry to include different colours of faces to reflect the four Zones of Regulation, a curriculum-wide ranking strategy in which children use colours to express how they are feeling. Teachers suggested that the incorporation of this into the MeCalendar design could help the children rank and self-regulate their zones throughout the day, also providing the teacher and parents with a record of the child's mood over time.

The work presented here suggests several future directions. Those discussed above - increased parental involvement, improved features for dexterity, integration of teachers' suggestions – will be addressed in a new iteration of the app. We also suggest it is imperative to focus on how best to support design contributions from children themselves in this research context. We aim to

apply a Speech and Language therapy approach to this problem, hoping to edge closer to understanding the true design needs of children with autism, especially those who are minimally-verbal.

6. CONCLUSION

In conclusion, this study has investigated the appropriation of a flexible support technology in classrooms by children with autism and their teachers. We highlight the importance of encouraging open-ended implementation and use, suggesting that such an approach can yield surprising results through empowering and leveraging the imagination, expertise and interests of our participants. Simple, audio-visual technologies can act as a catalyst for confidence in the expression of these interests and competencies. The findings here suggest a move towards a focus on child-led appropriation based on personal strengths and interests, as, when attempting to support and enhance child competencies and abilities, these are the true motivators of child experience and learning.

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