

Imagining a Digital Future: how could we design for enchantment within the special education curriculum?

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The implementation of the new “Successful Futures” curriculum in the UK, means that learners between the ages of 3 to 16 will be challenged to use digital media to develop their life skills, personal confidence, work skills, career planning, health and well-being (Donaldson, 2015). Teaching staff, responsible for delivering this multi-faceted programme for learners with profound disabilities, have reported that the perceived benefits of technology are misaligned to individual needs and capabilities. This is particularly evident when combined with a developmental approach that favours the achievement of milestones rather than discovery-led, task free, interaction (Simmons, 2019). The work reported here aims to directly address these gaps. We describe a series of *Digital Imagining* workshops, which set out to encourage creative and co-productive relationships between teaching professionals, academic artists, makers and computer scientists. During the activities, we experimented with digital fabrication tools as a means to envision contingent, imaginative interactions between learners with Profound and Multiple Learning Disabilities (PMLD), other people and their environment. In collectively critiquing the ideas developed during the workshops participants recognized the benefit of simple contingent, cause and effect actions for drawing attention to the material properties of objects. Almost seamlessly, these sensory explorations became the trigger for more complex ideas for integrating the demands of the digital curriculum into more natural daily scenarios. The shared process of ideation and tinkering was reported to be vital in generating a shift toward inclusion as a creative, imaginative and expressive counterpoint to the pervasive emphasis on utility and function.

Keywords: *digital curriculum; technologies; disability; enchantment; design*

1 Introduction

In the Autumn of 2019, the new “Successful Futures” curriculum will be implemented for learners between the ages of 3 to 16 in Wales, UK. The Successful Futures curriculum focuses on life skills, personal confidence, basic skills, work skills, career planning and health and well-being (Donaldson, 2015). The design of the curriculum has taken into account feedback from teaching professionals who wanted more power to make decisions on delivery and assessment, and children themselves, who felt that the existing provision for

technology, software and digital skills was out-of-date. The data gathered from nine months of consultation, revealed that children wanted “lessons to be fun, interesting and not something that there just to pass assessments or get qualifications” (Donaldson, 2015, p3).

The Enchanting Technologies project has emerged from prior research and consultation events in which teachers of children with Profound and Multiple Learning Disabilities, (PMLD) – some of whom had participated in the Successful Futures research - reported that, while the ambition of the curriculum opened opportunities for discovery-led digital learning, existing technologies were not fit for purpose. The barriers to using technologies in areas such as personal confidence and health and well-being, were reported to be cost and lack of flexibility to accommodate the diversity of learner abilities. For the more profoundly disabled children the perceived benefits of technology were misaligned to individual needs and capabilities, and the interaction lacked opportunities for personal agency through play, exploration and discovery.

In order to address this issue, we proposed to use Digital Imagining as a way of combining the real-world experience of teachers with our own interests in technology as academics, artists, makers and computer scientists. The goal of Digital Imagining was to propose a common language for creativity and entrepreneurship, in which the materials function as *“instruments of the imagination, able to enchant by movement, speed instantaneous communication and above all by bestowing upon us what cannot be fully grasped yet”* (Marenko, 2017, p. 30). The method focused on building a positive, exploratory relationship with the teachers, firstly, by using familiar paper tools as a means to describe the day-to-day ebb and flow of school activity, and, secondly, using digital materials to trigger ideas for imagining playful activities within a school environment. Further work needs to be undertaken to establish the impact of this approach on learners. However, using digital imagining to leverage the input of teachers, enabled us to collaborate on proposing a range of narratives that placed enchantment at the heart of the learner experience. With regard to the Successful Futures curriculum, this project has potential to reduce the barriers of inflexibility and cost, and to make the digital learning more meaningful and fun for learners with PMLD.

2 Background

2.1 Profound and Multiple Learning Disability

The term PMLD is used when a person has more than one disability, with the most significant being a learning disability. These people are among the most vulnerable in society, with poorer general health and more specific health needs - such as problems with hearing and eyesight, mental health and behavioural difficulties, epilepsy, thyroid disorders, heart disorders and dental problems - than the general population (NHS, 2018).

The World Health Organisation International Classification of Functioning, Disability and Health, (Children and Youth Version), addresses the need for integrated activities that enable individuals to have a high amount of personal autonomy over their lives (WHO, ICF-CY, 2007). Within this document emphasis is placed on the importance of relationships between the person with a disability, other people, and the environment, which is recognised to be an evolutionary and interactive process and subdivided into (a) Body Functions and

Structures, (b) Activities and Participation, (c) Environmental Factors, and (d) Personal Factors. Recommendations include providing assistance with the development of awareness of time and place, self and others, objects and space. Other recommendations, relevant to our aim of co-designing open-ended contingent interactions, include encouraging the ability to adapt to, and accept, new experiences, through positive, energetic activities that enhance curiosity, imagination, inquisition and emotional expression.

2.2 Designing Interaction

With the above recommendations in mind, Enchanting Technologies is building on research that addresses the importance of contingency on the development of the imagination, and expressive communication. In terms of interaction design, this means shifting the emphasis away from task or intended outcome, toward more experiential, open-ended and emergent possibilities.

2.2.1 Contingent interaction

In the context of child development, the term contingent interaction is used to describe the phase when children begin to take the actions of others into consideration and to display reciprocal actions in response to other people. Within the social sciences, this process is referred to as intersubjectivity, whereby successful social interaction is contingent on the development of shared understanding of the mental states of others, otherwise known as theory of mind (Baron-Cohen, 1999). Many disabilities and developmental disorders are characterised by more or less profound disturbances of intersubjectivity (Fuchs, 2015; Zlatev et al., 2008), which are reported to limit opportunities for contingent interaction (Cress et al., 2013). Emerging from anthropology (Csordas, 2008), psychotherapy, (Gieser, 2008) and linguistics, (Noland, 2010), the idea that intersubjectivity is dependent on theory of mind is being challenged and embodied and intersubjective research is coming together to shape the way in which human cognition is understood (Schmicking & Gallagher, 2009).

2.2.3 Embodied learning

Embodied learning is of particular interest to interaction designers (Harrison & Sengers, 2011) where notions of contingent interaction have moved beyond interface semiotics toward full body interaction and felt experience. In other words, naturally and bodily felt human-material interactions and kinaesthetic creativity (i.e. designing, creating and exploring future solutions through movement) constitute rich resources to inform design (Svanæs, 2013; Levisohn & Schiphorst, 2011).

Malinverni and Schaper (2018) suggest that contingent enhancement should be considered as a quality in embodiment interaction design i.e. digital augmentation should be contingent to the feature of the embodied experience. They propose “the quality of contingent enhancement as the degree to which digital technologies can make some aspects of the embodied experience richer and more interesting” (Malinverni & Schaper, 2018, p. 8).

2.3 Relevant Research and Development in Interaction Design

Research into task free, contingent, human-material interactions in relation to profound disability is relatively sparse as the design of technology has traditionally focussed on assistive devices that help communication and the acquisition of information (Achmadi et al., 2012; Campigotto et al., 2013; Flores et al., 2012). Instructional technologies such as social

stories, which use multimedia (for example, digital video composition) are favoured as a means to help children with learning difficulties understand social cues and potential responses in different situations (Porayska-Pomsta et al., 2018; Spencer et al., 2008).

Whilst there have been several examples of game platforms and movement sensing technologies being used successfully with to support playful, experiential interaction for children with learning difficulties (Kontogeorgakopoulos et al., 2014; Keay-Bright, 2011), a problem with the technology is the difficulty in adapting software for individual abilities. Although many platforms offer developer kits, the level of programming experience required for customisation or making original applications, is beyond the scope of most teaching professionals (Márquez Segura et al., 2016; Simon, 2009; Tanenbaum, 2015). Similarly, virtual reality and augmented reality (Billinghurst et al. 2015; Gillies, 2016), are generally overly complex to customise for non-experts interested in experimentation, sustaining longer-term experiences and expanding learning opportunities.

From the point of view of Enchanting Technologies, we are interested in body movement as the core of interactive experience. Shusterman describes how our bodily movements, sensations, and somatic training, are central to being and thinking in the world, which have led to the development of the somaesthetics theory (Shusterman, 2008). These ideas are expanded upon from a practice perspective through the work of Hanna, who defines somatics as the field which studies the body – the soma - as perceived from within (Hanna, 1988). Whereas Descartes states: “*To think is not merely “to be” passively; it is to move*”, Hanna’s view is “I am self-aware, therefore I act” (Hanna, 1991, p. 33). This first-person perspective respects bodily awareness as central to human agency, which contrasts with the third person perspective of the sciences, for example psychology, which sees bodily acts as behaviour, responding to the universal laws of cause and effect (Hanna, 1991, p. 31). Responsive, interactive artworks that bring movement into consciousness, have been tested in different contexts by Hansen and Keay-Bright (2017). These studies have revealed unprecedented levels of unscripted experimentation and creative flow from children on the autism spectrum and adults with PMLD (Keay-Bright, 2018), when their body movements are made visible. Höök et al. (2018) argue that “*novel ways of engaging with our soma cannot be ‘put into us’—we cannot be moved into shape. The concept of self-agency in somatics practice is key. Self-agency is the result of the reflective practice of self-observation coupled with intention*” (p.6). Notable somaesthetics works are discussed briefly below.

BrightHearts is an interactive artwork and biofeedback application for smart handheld devices and used as a tool for reducing pain and anxiety amongst children undergoing medical procedures (Khut et al., 2011) In *BrightHearts*, the user’s heart rate is coupled with the diameter and the colour of a collection of overlapping concentric circles visually presented on the handheld. The more relaxed the child is, the less bright and warm colours appear at the interface i.e. the child can explore ways to decrease his or her average heart rate through a combination of muscle relaxation, slow breathing and relaxing memories in the application space. The relaxed child is rewarded by gentle chimes, and new layers of colourful circular imagery.

Höök et al. (2016) provide two example prototypes developed through their workshops with design exemplars: the *soma carpet* and *breathing light*. With *soma carpet* the mat is designed such that heat stimuli directs user’s attention to different part of the body parts

while the user follows audio recorded instructions. For example, when the instructor says, “How does your body contact the floor right now under right heel?”, the mat heats up under user’s right heel. The mat is aimed at increasing the body awareness. The authors report that while engaging in these somatic exercises, the user sometimes feels pain, aches and bodily memories surfacing during the exercise (Höök et al., 2018). To reduce user’s vulnerability, the carefully designed thermal mat provides enclosure and softness. In *breathing light*, the aim is to create a room for reflection (Höök et al., 2016) The prototype has a fabric-based enclosure, where the user can crawl underneath and shut out the external world. Inside the enclosure, a breathing sensor measures the user’s breathing pattern and controls a lamp inside the module. A lamp creates an ambient light that will dim in cadence with the breathing. *Soma carpet* and *breathing light* can complement each other when used together.

With overwhelming evidence to support the role that gesture and bodily action play in the process of thinking (Ishii, 2012; Kirsh, 2013; Osgood-Campbell, 2015) and the recognition that cognitive, social, emotional and physical development are co-dependent processes influenced by bodily sensations (Ishii, 2012), we are focusing our initial explorations on body sensing technologies as triggers for imagining and relating to contexts that can include others.

2.4 Maker Movement in Education (or Maker Education)

Maker education is a term that applied to a wide variety of activities such as household DIY, computer programming, and sewing where hands and mind are engaged. Maker education supports academic learning and the development of a mindset that values playfulness and experimentation, growth and iteration, and collaboration and community (Halverson & Sheridan, 2014).

Maker education attempts to solve a particular problem initiated by one or a community of users, to create a physical or digital artefact, and share that product with others. In maker education the process of making is often more important than the product.

The rise of affordable digital maker tools, including microcontroller platforms such as Arduino, rapid-prototyping tools such as 3D printers, and online community of makers such as Github, Hack Clubs, Kickstarter have in recent years empowered people even without university degrees or formal education to use such tools and or participate in making digital products (Niezen et al. 2016). Therefore, maker education has enhanced diversity, inclusivity and equity, which many observers view as much needed in a movement that has tended to focus on the interests and experiences of middle-class white males (Vossoughi et al. 2016).

Finally, key to an effective maker education that works for all in the education system is facilitating “playfulness”, encouraging “resourcefulness”, ability of students and or teachers to draw not just on their own internal skills and experiences, but the assets of other people and their communities known as “participatory design” (Sheridan & Konopasky, 2016).

3 Methods

“...methodology should not be a fixed track to a fixed destination but a conversation about everything that could be made to happen.” Jones, 1991, p.32)

In the 1970s, long before computers became personal and ubiquitous, Welsh designer, John Chris Jones, addressed the need for design methods that attune to the changing landscape

of human relationships with technology. Motivated by the functional and aesthetic failure of design to adapt to local physical and social environments, he advocated that rather than consider methods as things, they should instead focus on relationships, or “ways of enabling things to get into better relationships with each other” (Jones, 1992, p.6).

The overarching aim of Enchanting Technologies is to enable teaching professionals from the special educational sector and children with disabilities to take an active role in exploring the creative interplay between the design process and the digital artefacts that emerge. We are calling this method Digital Imaging, which constitutes a series of workshops using digital fabrication to open up conversations and trigger the imagination. Our partners in Digital Imaging include teachers working with pupils with a diagnosis of autism and PMLD as well as health experts providing specialist, residential provision for autistic students in further education (post 16); other professionals in our group include representatives from Occupational Therapy, IT specialists and management. These partners elected to join the project on the basis of prior experience of collaborating with the research team. Their detailed understanding of children and the changing landscape of the digital curriculum provided the grounding for the project. Their determination to improve the lived experience of learners brought additional motivation that could not be approximated by designers taking on the role of users.

Whilst the need to address the challenge of the new curriculum provides the motivation for Enchanting Technologies, the overarching goal of Digital Imaging is to facilitate a relationship that taps into the real-life experience of everyone concerned. In this respect, the research team and the teaching professionals are co-dependent. Rather than attempt to implement a method whereby designs become concrete through iteration and testing, our interest is in exploring the role that technologies could play in imagining and unlocking untapped creativity. Such relationship building, whilst understood to be core to the user-centred design, rarely achieves a genuine balance of ownership within project hierarchies.

We were inspired by the workshops done by Mogensen and Trigg (1992) and Frauenberger et al. (2016), where designers and practitioners are seen as active cooperating subjects investigating current practice. Mogensen and Trigg (1992) formulate a joint enterprise linking three perspectives (depicted as three vertices in a triangle): research (analysis), design, and practice. They see “the activity primarily as involving reflection on practice, either one’s own or another’s” (p.3). Their response to this challenge is that simultaneous changes in all three can be triggered through the use of concrete artefacts in workshops between developers and users. Following Mogensen (1992), Hartmann (2009) and Preece et al., (2015) we see an artefact as not only triggering discussions of future technologies and practices represented, or suggested, by the artefact, but also as triggering penetrating discussions of current practice.

The term *artefact* here is used to denote two different kinds of objects and prototypes. On the one hand, the physical nature of an artefact implies *persistence*, something concrete lasting over time. At the same time, the term artefact suggests deliberate and purposeful creation by human hands. In our workshops, both aspects were crucial: “*the persistent nature of the artefacts’ forms, and the appropriate, appropriable, and provocative nature of their contents*” (Mogensen & Trigg, 1992, p.3).

3.1 Digital Imagining Workshops

The Digital Imagining workshops factored in the need to discover enchantment within the day-to-day routines and experiences of pupils with profound disabilities, and to identify the barriers to inclusion (e.g. pragmatics of co-design and ethics). In Workshop One we used visuals such as videos, storyboards, drawing and sketching to gain insight into the day-to-day routines and experiences of pupils with profound disabilities, and to identify the barriers to inclusion (e.g. pragmatics of co-design and ethics). In workshop one, *movement*, we included teachers, policy representatives and experts from movement theory and education, therapy and performance.

In Workshop Two, *Enchantment*, we used a tinkering approach (Hendriks-Jansen, 1996), in which everyone was invited to explore existing and off-the-shelf coding and material that had the potential to be easily modified. This workshop focused on requirement gathering, using digital maker tools to reimagine existing situations and model new possibilities, prioritising ideation over functional detail. The workshops are described in more detail below.

3.1.1 Workshop One

Eight professionals from five special education schools and a further education college participated in the first Digital Imagining workshop with five members of the research team, who were also practicing artists and designers. The workshop was convened at a special school where we focused on building a relationship through the identification of complementary skills and interests. We began the workshop with a collective activity that was designed to quickly capture the level of motivation, expertise and creativity of all participants. To give everyone an opportunity to comment, each participant was given a set of coloured Post-It® notes, bright pink for the special education partners and blue for the research team. Everyone was invited to contribute 10 keywords about their work using a separate note for each word. Next, the activity was repeated with everyone noting 10 challenges they experienced in supporting digital engagement. All the Post-It® notes were collected and assembled onto large sheets of A1 flip chart paper and made into Post-It® artworks, the idea being that even something as ordinary as a Post-It® could be enchanting. The colours revealed the source of the idea but maintained anonymity (Figure 1).



Figure 1. Workshop One, collecting participant viewpoints and ideas

The notes revealed that teaching professionals were motivated by the need to increase pupil engagement and to improve the effectiveness of technology use, particularly supporting sensory integration across a range of needs. Barriers to engagement included the diversity of needs, lack of training resources for teachers, lack of flexibility, benefits of technology misunderstood or misaligned to the needs of profoundly disabled children. The perception of low-tech technologies was that it was not as useful as high-tech, with not enough access to playful technologies or play activities in general for children with PMLD.

For the research team the motivating factors were noted to be the importance of collaboration, learning from each other, generating meaningful, impactful research, sharing knowledge, discovering and maximising on the curiosity of learners and having fun. It was noted that materials could be useful for discovering new ways to connect and make a difference to others. However, there was a notable divide between higher education research and the needs of people in the real-world, and suggestions that technological determinism can make innovation overly complex.

The next exercise involved the teaching professionals sharing examples of current technologies, classroom activities, and experiences that they, or their pupils, found interesting. They described a rich array of products, such as the LilyPad Arduino board, RFID tags, robots, interactive floor mats, Electrop plankton (2009), plastic recycling ("Precious Plastic.", 2016), story dice, conductive blankets and virtual reality headsets. With an emphasis on body sensing technologies, the researchers demonstrated devices that emphasised 'making', such as Arduino, Raspberry Pi, conductive paint, and augmented reality markers, plus ideas from the maker movement ("FabCre8 Maker Lab.", n.d.) and IFTTT ("If This Then That (IFTTT)", n.d.), somaesthetics (Höök et al., 2016), kinaesthetic awareness (Hansen et al., 2017) and play (Lewis, 2017).

In order to encourage responses to these demonstrations, we re-used the Post-It® technique and invited 10 comments from each person on interactions that had inspired them (Figure 1).

The final activity was conducted in mixed academic/professional groups. Each group was invited to use paper-props to create a short story in which technology could enchant learners, and to present their ideas as a storyboard or paper-prototype one-minute pitch. These simple paper-based interactions enabled teams to express ideas fluently and intuitively. With an emphasis on digital materials rather than task, the discussions focused on opportunities for discovery-led learning, for example, through the sense of pressure or touch, with technologies that afford haptic feedback employed to encourage greater attention on the possibility of interaction. Feedback and contingency were noted to be key to engagement, with the timeliness of response adapted to suit different processing abilities. Adding causality to visual or audio outputs was suggested as a means to capture attention, leading to further ideas of how contingent interaction could be encouraged on the basis of the emergent creativity and self-expression of pupils. These ideas were further played out in the short stories, which ranged from virtual school pets to treasure hunts, using RFID tagging or connected objects.

Following the workshop, we began the process of organising all the notes into ideas for digital props that could trigger casual, contingent interaction. We chose the themes of Soma, Optic and Sonic (SOS) to concentrate on simple bodily sensations. The technologies selected for this purpose deliberately made the materiality visible, for example, pressure sensitive resistors, proximity sensors, ultrasonic sensors, vibration motors, accelerometers, gyrometers, heat/motion/vibration actuators and an open source AR marker application. With ideas for bodily interaction based on these technologies, we set about making simple prototypes in readiness for the second Digital Imaging workshop.

3.1.2 Workshop Two

The second workshop was conducted in our University fabrication lab with the same team of professionals, plus two additional special education participants. The core findings from the first workshop were revisited followed by demonstrations of the SOS prototypes (Figure 2). Rather than draw attention to the functionality of the technologies, we sought to expose the rawness of the materials and to invite conversations on how they could afford opportunities for causality.



Figure 2. Tinkering with materials to produce optical and sonic effects

During the next stage of the workshop we encouraged tinkering with the prototypes, and each of the participants naturally clustered toward the prototypes that interested them. Each cluster was assigned a technical expert and academic partner, and together they experimented with the prototypes, writing or drawing ideas for real life scenarios, which seemed to flow naturally within the conversation stream. At the end of the day, all the ideas were pinned to the wall and presented to the whole group.

Scenarios ranged from a treasure hunt navigation system using RFID tags to generate individualised props, to pressure and movement sensitive hand-held puppets that could be connected to other devices. Opportunities for embedding sensors into favourite textures and objects were suggested as means of facilitating experimentation with sonic and optic effects to encourage social interaction with staff and peers. At the end of the session, the partners unanimously agreed that in order to better understand the potential of any of the technologies, it would be vital to be able to rapidly test interactions, and to establish a responsive 'maker' network prototyping.

4 Discussion

Anthropologist Alfred Gell's description of technological capacity as a medium of production (career skills, life skills, basic skills), of reproduction (social communication) and of enchantment, (creativity, health and wellbeing) (1992) affords an opportunity to explore how better to connect humans and technology within the new curriculum. Digital Imagining workshops enabled the direct involvement of teaching professionals in designing with materials - from paper to technical components. The impact of this method has been to give confidence to creative exchanges as the building blocks of a more dynamic and magical relationship between people, contexts and environments. Below we describe the three main discussion points that need to be factored into future developments.

4.1 Digital Imagining as a process

"The enchantment of technology is the power that technical processes have of casting a spell over us so that we see the real world in an enchanted form", (Gell, 1998, p. 44).

Our workshops encouraged collaboration on imagining enchanting and creative applications for low cost technologies. The academic partners commented that through digital imagining, the design process was more discovery-led and playful. Teachers stated that the workshops revealed that technologies for children with PMLD do not need to be complex to respond to the diversity of needs and need not require exhaustive training sessions. Furthermore, knowing how to adapt and customise devices can extend use in response to the child's needs and or the context of use.

Workshops can be employed as analytical lenses during research with teachers and children with PMLD in co-production design cycles. In particular, we consider that enchantment and causality features make them particularly suitable for understanding interactions beyond usability, task-completion and effectiveness in learning.

4.2 Contingent interaction and enchantment

When the teaching professionals developed scenarios through materials, we noted that they naturally converged on ideas around enchantment. Even though they employed different

somatic and aesthetic strategies to accommodate the diversity of learner ability (e.g. body massage, warm bath and swimming), there was a shared understanding that digital tactics could make such experiences more intriguing. Ideas such as slowing down movements with colour changes or discovering environmental clues; disrupting the habitual movement to help grasp and articulate on a story; directing attention to specific areas of the body with sound or heat and putting sustained attention to body parts or cues in the space, all implied an intrinsic connection between the body, technology and enchantment.

4.3 Scaffolding creativity

Finally, the digital imagining workshops served as useful meetings for building confidence in teaching professionals through the articulation of shared values. On a latter point, as Levisohn and Schiphorst (2011) point out, often the traditional interaction design pedagogy tends to neglect training users or conversations about experiential qualities such as enchantment, contingency and embodiment. Hence, we need tools and approaches to help teachers to think about embodiment and for researchers to draw on the nuances and differences of individual experience.

The goal of the first workshop was discover a mutual vocabulary for creativity. The non-digital props opened up possibilities for conversations, without imposing a structure, allowing us to maintain a degree of flexibility in moving forward. The scenarios and stories created by teachers in the workshops, demonstrated a willingness and commitment to explore enchantment and contingency, and to set a direction, rather than a solution, for future digital engagement.

Inspired by these scenarios our simple Soma, Optic, Sonic prototypes, became the basis for experimenting with inter-subjectively constructed meanings for both academics and teaching professionals. The teachers realised that creating enchanted objects with off-the-shelf digital tools could be fun, rapid and easy to test in the classroom with children.

Both parties experienced the tangibility of design as a process of connecting with tacit aesthetic sensibilities such as movement, to the degree that discussions emerged for how this designing could become a classroom-based practice that could render different results depending on individual and context. Rather than describe how the digital environment could improve access, conversations shifted toward how each interaction could lead to discovering possibilities for the next.

5 Conclusions and Future Work

The design of technologies, for most people, remains a mystery. We are surrounded by devices and interactive objects that are made, typically from a rationalised, operational process. The mass production and ubiquity of personal computers has diminished our relationship with technology as a source of enchantment. Moreover, ubiquitous devices and their programming still remain a complex process and require extensive training in programming and computer science.

Through the first Digital Imagining workshop, we created a design space, in which we used simple paper-based materials to create a picture of the learning context. This was followed by further ideation, that added some digital magic, by coding ideas into simple bodily inputs and outputs (how to design for the body and with the body to explore the body).

In the second workshop, we used demos of aesthetics design, such as bodily inputs and outputs (how to design for the body and with the body to explore the body) to further probe context, motivation and the triggering of imaginative ideas, to maintain a dialogue for designing with teachers. We used fabrication tools to make the digital tangible, offering hands-on experience of materials, such as easy to program and off-the-shelf microprocessors, sensors and actuators. In order to make digital imagining more palpable, we used a collaborative tinkering approach to trigger ideas for real-life scenarios. We also modified existing and off-the-shelf software using modular programming technique, which is common for microprocessors suitable for maker culture (e.g. Arduino, Touch Board, Teensy and Raspberry Pi). We are intending to use this technique further in our next workshop as a means to separate the functionality of a program into independent, interchangeable modules, such that each contains everything necessary to execute only one aspect of the desired functionality (Gosling et al., 2005). This allows novice developers to reuse code whenever and wherever they need, to perform the same or similar task in a different context.

Planned future work on this project will enable us to develop technologies directly with learners with PMLD. Feedback from teachers stressed the importance of Enchanting Technologies as a community of practice for sharing prototypes and stories, without which designing with children would not be feasible. Collectively, we see this as a window of opportunity to discover the enchantment of technology by attuning to the competences of children with profound disabilities.

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