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Disabled Young People as Researchers, Designers and Makers: Aligning Makerspaces, Co-production and Critical Disability Studies

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Abstract

This paper considers the research possibilities afforded by disabled young people as researchers, designers and makers. We centre an interdisciplinary research project that sought to bring together critical disability studies, co-production and makerspace methods when exploring disabled young people's aspirations in developing new automated technologies. This emerges from makerspace workshops in collaboration with 9 student co-researchers at a SEND school in the UK. From these workshops, we learnt lessons about the possibilities of starting from assumptions of capacity with disabled young people, promoting the affirmative qualities of making, and the role of interdependencies when researching and making together. Our workshop encounters demonstrate examples of the significant theoretical and methodological possibilities that emerge when bringing together making as a collaborative research practice within critical disability studies. Our workshop examples illuminate the entanglement between makerspace methods, co-production and critical disability studies. These alignments of affirmative methods and theory make for not only an affirmative process of capacity, diversity and difference but a celebration of it. As such, this paper offers a novel contribution in centralising makerspaces within critical disability studies, and the value of disability as the driving force of inquiry within collaborative, creative and maker methods.

Keywords

critical disability studies – co-production – makerspaces – Maker education – participatory methods – inclusive pedagogy – disabled young people

Introduction

This paper emerges out of a UK Research and Innovation (UKRI) funded project entitled, 'Reimagining Trustworthy Autonomous Systems with Disabled

Young People'. This work brought together a interdisciplinary research team of social and computer scientists,[1] and significantly, disabled young people. Our project aims were to interrogate the perspectives, experiences and aspirations of disabled young people in relation to new developing technologies for autonomous systems. Autonomous systems are technologies that we might use, or are soon to use, in our everyday lives (see UKRI TAS Hub). There has been an ongoing inclination to conceptualise disabled people as end users of new technologies (if they are considered at all) – and trustworthy autonomous systems are no exception. Disabled young people's perspectives, experiences and aspirations are rarely acknowledged in design processes. While there are increased efforts in equality, diversity and inclusion (EDI) and responsible research and innovation (RRI), barriers still remain for disabled young people across education, employment and industry (UK-RAS, 2021). This aligns with the theory of disablism which recognises the social oppression and restrictions imposed on people with impairments (Thomas, 2007: 73). Our project sought to address this by positioning disabled young people as *researchers, designers* and *makers*. We considered what methods could be adopted to promote equity, diversity and inclusion in relation to autonomous systems, centring co-production and makerspaces to enable a meaningful engagement with and for disabled young people.

In this paper, we make a case for bringing together three key points of alignment: Critical Disability Studies, Co-production Methodologies and Makerspaces. Kay and Buxton (2024) in their work on makerspaces advocate for what they call the 'Maker{Spirit}[2]': a nurturing spirit that supports 'out of the box' thinking and a mindset to see the world full of possibilities. With our co-production and critical disability studies ethos, we echo this approach of supporting such spirit by celebrating disabled young people as co-researchers, designers and makers of technology. First, we review contributions from critical disability studies which view disability as the driving force of inquiry, and which we see as entangled with methods of co-production (Goodley, 2024; 2020). Second, we tease out participatory methodologies and politics within this which we seek to match up and align with, makerspaces modes and methods. We then detail information about our project and what we did. Our analysis then centres around the themes of capacity building, cultures of

1 Reimagining Trustworthy Autonomous Systems with Disabled Young People – Our research team (google.com).

2 The use of {} are symbols affiliated with the Maker{Futures} organisation at the University of Sheffield.

collaboration and finally, positioning disabled young people as designers and makers. Our paper considers how makerspaces can facilitate co-production, and how co-production philosophies, politics and processes offer alignments for those working in educational makerspaces research and practice. We push disability researchers to consider making as a form of agentic participation and research co-creation. A collaborative and Maker{Spirit} (Kay & Buxton, 2024) allows us to affirmatively tap into the experiences, aspirations and expertise of disabled young people. Our paper offers a novel contribution by engaging with scholarship across critical disability studies; co-production and the maker movement and their crucial intersectionality.

Critical Disability Studies

Critical Disability Studies (CDS) (Goodley, 2024; 2020) addresses disability not as an individual condition requiring rehabilitation, treatment or cure but as a phenomenon through which to rethink the world. It is an interdisciplinary field of research that starts but never ends with disability (Goodley, 2024): recognising that disability always intersects with matters of race, gender, sexuality, class and place (Meekosha & Shuttleworth, 2009). Over the last decade, critical disability studies scholarship has become more attuned to the distinct though complementary social processes of ableism and disablism. Ableism involves the social assumptions and biases against people whose bodies function differently and occurs when able-bodied-and-mindedness is presumed and idealised (Goodley, 2024). Ableism assumes ability and assumes the presence of a standard citizen: ready, willing and able. This matters for everyone as it is tied to ideologies of neoliberalism and individualism, and as we shall see shortly, makerspaces can also be a rejection of consumerism and capitalism. Comparably, disablism occurs when people with physical, sensory or cognitive impairments are excluded from mainstream society. Disablism is 'a form of social oppression involving the social imposition of restrictions and activity on people with impairments and the socially engendered undermining of their psycho-emotional wellbeing' (Thomas, 2007: 73). The social model of disability is particularly engaged with disablism. So, for example, if technologies are housed or showcased in an inaccessible building or technological products have no in-built accessibility to them then we can understand such experiences as disablism. Disablism impacts disabled people. As critical disability studies scholars, this involves challenging and exposing the buildings we inhabit as ableist and rethinking

the makerspace activities we practise to avoid designing with the idealised notion of an able-bodied and able-minded maker in mind. Further to this, critical disability studies is also about centring disability as the driving force of inquiry for meaningful and inclusive making and makers.

In seeking to foreground the lives of disabled people, scholars have argued for the need to *desire disability* (McRuer, 2006; Kafer, 2013). This literature has been defined as 'crip scholarship'; a reappropriation of the traditionally derogatory term 'cripple' and reframed in more positive ways as identity (crip) and practice (cripping). Hence, were we to crip technology, we would draw on disability as an opportunity to remake our technological products as more inclusive and welcoming. Critical disability studies researchers cast disability as an object of research (worthy of researching in its own right) but also a driving subject of inquiry (the entry point into conversations around research and innovation). We therefore position disability front and centre: as *the* conversation starter.

Critical approaches to disability propose that research should address exclusion by centering disabled people as expert-by-experience in their own lives. A key leitmotif of the disabled people's movement is 'nothing about us without us' (Charlton, 2000; Wellcome Collection, 2021): demanding that research should not be solely accountable to disabled people but rather they must be involved as co-producers of knowledge. Critical disability studies recognises the importance of working with disabled people as *co-researchers* and *experts-by-experience.* Further, we are encouraged to design research projects that involve *disabled people as researchers, leaders and makers.* In our project, centralising disabled young people as researchers is important because, far too often, their experiences, aspirations and expertise are conspicuously absent. Our paper advocates for critical disability studies not only entangled with methods of co-production, but of makerspaces too.

Participatory Research and Co-production

Co-production carries with it a history committed to social justice, civil rights and emancipation (Oliver, 1992). Co-production is a form of participatory research that centres ethics, collaboration and community-engaged inquiry (Guta & Voronka, 2020), giving communities greater control over research (Durose et al. 2012). It could also be known as Community-based participatory research (CBPR) (Duke 2020); Community-engaged research;

Participatory Action Research (PAR) (Kemmis, 2006); and Co-production (Liddiard et al. 2022), to name just a few. In the field of technology, we must also acknowledge the long trajectory of User Centred and Participatory Design as having similar alignments albeit differing articulation (Bødker & Kyng, 2018; Sanders, 2002). Such work highlights the importance of involving stakeholders in design and thinking through equality, diversity and inclusion within their useability (Rutter et al., 2024). There are important distinctions in shifts from user-centred design and co-production methods (Sanders, 2002). It is not only about the research and design process *for*, but *with*. Research needs to be done *by* those in which the subject of inquiry involves. For us, this is disabled young people as researchers, designers and makers of technology. Beyond such disciplinary definitions is a shared commitment to redistributed power, valuing what we all bring to the table in our diverse experiences and ways of being. Participatory research methods and co-production centre a relationality of mutuality, respect, collaboration and trust which are key to co-creating research and knowledge with disabled young people (Liddiard et al., 2002; Hemström et al. 2021; Clarke et al., 2021). Trust takes time to build (Armstrong et al., 2022) and prior to our makerspaces work, we came to co-theorising trust as not only trust in technologies, but being *trusted* to lead, shape, design, imagine and make (author removed for review).

Our young co-researchers were collaborators in driving not only the conversation but the research process. The research was not about or for them, but rather conducted with and by (Liddiard et al., 2019). Disabled young people, in particular, are often treated in tokenistic ways by research inquiry, considered as having the capacity to participate in certain areas but excluded from others (Nind 2008; Liddiard et al. 2019; Bailey et al. 2014). Emerging models of research, such as Disabled Children's Childhood Studies, have challenged such adult-centric tokenism, valuing children and young people's voices as critical to authentic research. Disabled Childhood Studies actively positions disabled children and young people at the centre of inquiry (Runwick-Cole et al., 2018). In our project, they are not seen as solely end users of technology, but they are the knowledge, imagination, aspiration, creation and production behind it. They are knowledge producers, creators, designers and significantly, they are *makers*. This now leads us on to reviewing substantive and methodological insights from the maker movement and what we believe is an alignment with Critical Disability Studies and co-production methodologies. This alignment comes in the democratic, inclusive and affirmative potential of being, working and making together.

Makerspaces, Maker{Spirits}

Maker education is a growing international movement which provides children and young people with the skills, knowledge and habits of mind to make projects in relation to real world problems using both high- and low-tech tools, materials and technologies (Marsh et al., 2017, Sheridan et al., 2014). It is a philosophy and a pedagogy, which combines arts and science and pushes disciplinary binaries to focus attention on methodological process. As a simple definition, a makerspace is a space in which people come together to create, share resources, knowledge and build together. This is particularly the case for children and young people developing the Science, Technology, Engineering, Arts and Mathematics (STEAM) agenda for future opportunities and employment (Gov UK, 2019). Drawing on Papert's theory of Constructionism (Papert, 1991), makerspaces provide a DIY learning environment for learning by doing and tinkering with materials, technologies and tools (McLean & Rowsell, 2021; Wohlwend et al., 2018). They encourage the development of skills and knowledge to create, make and mend things, but also support creativity and critical thinking through nurturing a maker mindset. Dougherty (2012) conceptualises makerspaces as open and optimistic spaces for democratic design (Blikstein, 2013; Rose, 2014) where makers (in our case, disabled young people) are central to decision making. This includes deciding what is being made and how: not dissimilar to processes of co-production. Dougherty (2012: 11) states, 'We are all makers' dispelling the idea that one needs specific competencies or 'creativity' to make. Tinkering is key to makerspaces and allows for a playful process of possibilities, adaptation and productive problem solving. Makers experiment but are not positioned as 'failing' if the making is not 'successful'. Makers are positioned as active participants, collaborative team members and always with capacity (albeit it diverse and always in relation). This aligns with critical disability studies and co-production which celebrates the contributions of all (Liddiard et al., 2022). Further to this, what makerspaces and critical disability studies also have in common are disruptive capacities. Makerspaces is politically charged, entangled with activism, anti-consumerism, recreating and hacking at (e.g. repurposing, tinkering) what might currently exist or be the status quo (Dougherty, 2012; Resnick & Rosenbaum, 2013). This similarly aligns with crip theory and methods which seek to subvert social norms and allow disabled bodies and minds to lead and shape the way (McRuer, 2006; Kafer, 2013).

Whilst much of the makerspace movement has focused on the democratic processes of involvement (Andrews & Boklage, 2023; Bosse et al., 2018; Steele

et al., 2018), more is needed when it comes to disability access and inclusion. Many makerspaces (places, materials and tools) are inaccessible to disabled people (Brady et al., 2014). Failing to centre disability in makerspaces results in physical and digital exclusion, and further marginalisation (Jaeger 2012; Thompson et al. 2014). Brady et al. (2014) advocate that access and participation to makerspaces is one of many avenues in which disabled people can 'thrive and experiment with problem solving' and be part of a space in which there is fun, education and meaningful activity (Brady et al., 2014). Brady et al. (2014) suggests that makerspaces groups should work to engage communities, considering diverse abilities and to adapt making accordingly. Opening up makerspaces offers huge potential, made evident by Hackcessible workshops (Goodley et al., 2021). Hackcessible workshops align with theories of hacking previously mentioned, where there is a rejection of the normative and ableist processes are reimagined, repurposed and creatively engaged with through the lens of disability. Hackcessible demonstrates that through inclusive social, cultural, technological and material practices, the capacities of disabled people are strengthened (Goodley et al., 2021). There has been increasing interest in the role of disabled people in the design and development of digital practice (Jaeger, 2010; Lewthwaite, 2014; Goggin, 2018) and of universal and inclusive design (Pullin, 2011; Boys, 2014; Hamraie, 2017). Studies have centred disabled people in the research design and production of assistive technology (Boccardi et al., 2022) and the co-production of aids through makerspaces (Bosse & Pelka, 2020).

Whilst this progress is something to celebrate, the makerspaces process needs to allow the imaginative agenda setting to be inclusive in order to push the critical disability studies agenda. This means that we should not reduce involvement in design purely to questions of access and impairment aids, but rather to centre creativity, fun and inclusive participation across all spheres of disabled people's social lives. Something our project strived to achieve.

About the Project

Our project worked at centralising co-production, critical disability studies and makerspaces as guiding epistemologies and methodologies to facilitate our understanding and to (re)imagine possibilities for inclusive future technologies. Despite the increase in interest in such technologies, we carried a critique about how such technologies might not be inclusive of all futures (Morgan & Tutton, 2024). Our critical literature review explored how TAS can be framed within a critical disability perspective, questioning how disability

is conceptualised, methodologically explored and represented within the autonomous systems field, suggesting how future research must centre disabled young people (author removed).

We worked with nine student co-researchers based at a Special Educational and Disabilities (SEND) school in South Yorkshire, UK. This school was selected as a collaborator as a result of longstanding research partnerships with the broader research team and importantly, trusted relationships (see Liddiard et al., 2022). Students were aged between 12–18 years old, mixed gender, had a diversity of impairments (physical and cognitive) and were predominantly White British which is reflective of the broader demographic of the rural area the school was placed within South Yorkshire. We recognise the limitations of this and advocate for ethnically diverse research and an inclusion of broader protected characteristics and social identities in the future. In the context of educational development, the school adopted an 'age not stage' approach to organising students' classes. We were also supported by two school teachers who are named as co-authors and who worked closely with us to invite students they felt were appropriate and would benefit from involvement in the research. The school describes the things they care about as 'environment – inclusion – commitment – connections – magic' which we interpret as aligning with the affirmative capacities of critical disability studies and that of the maker{spirit} (Kay & Buxton, 2024). Our project received ethics approval [School of Education, The University of Sheffield] (No: 046474). We employed a participatory approach to our ethical processes which included consulting with our school partners on our aims for the project, as well as their role in facilitating consent processes and carefully mapping risks in relation to identification and safeguarding procedures. We included easy read information to sit alongside institutionally guided documentation, which were important for student co-researchers, their parents, guardians and the school. Due to the varying project activities across the year, we revisited consent and worked closely with our student co-researchers to consider contributions and acknowledgements as central to outputs and dissemination. These relational and ethical dimensions are entangled with our principles of participatory design, critical disability studies, and our makerspaces practices.

This project was split into two work packages. The first work package, 'Imagining TAS' adopted co-production to explore disabled young people's perspectives. We built trust as a team and asked big questions such as 'What is trust?' 'Do we trust technology?' and 'How is trust shaped, made or broken?'. Part of this conversation included trusting those who make and design technology. We also thought about how technology might be useful in our lives

and the lives of our family and friends, with fun, play and supporting others as central. This scaffolded our makerspaces work, building trust and relationships within our research partnerships and collaboration. The second work package, 'Reimagining TAS' built upon the first, drawing upon makerspaces practices to explore the aspirations of disabled young people in relation to TAS. We had three workshops with the team, Maker{Futures},[3] who builds on the philosophy of the wider global maker movement (Blikstein (2018). The team developed a set of pedagogical tools to facilitate Maker{School} pedagogies and practice which include the maker{Cycle} and the Maker{Spirit} (Kay & Buxton 2024). To help educators design learning experiences that build practical skills and develop this Maker{Spirit}, the Maker{Futures} team uses a three stage process of making: Exploration, Skill Builder and Tinker time (Maker{Futures}, 2020).

Image description: A Maker{Futures} infographic that describes key components which include being: innovative; creative; curious; collaborative; resilient; autonomous and critical.

3 makerfutures.org.

Maker{Futures} methodologies were used in our three workshops to enable students to think and create like makers. It was important to support them in making that shift from being technology users to exploring what it means to be *the* designers and makers. Our work with Maker{Futures} was integral to our methods of co-production and forms the crucial component of this paper.

The first makerspace workshop was all getting to know each other and building trust (lead author removed for review). Our Maker{Futures} team explained their roles and shared some of the things they had made. As a group, we talked about things we had made that we were proud of such as baked goods, badges, clothes, bracelets, pottery and technology. We all shared things we struggled with – such as maths, coding, writing, household chores, being patient or working in big groups. Our next activity was making researcher names. Our university research team members explained some of the principles of research and ethics and the importance of names or keeping our names a secret so people can't identify us if we don't want them to. We explained that as they were co-researchers in this project, they could also write this as a part of their badge. Students were supported by the Maker{Futures} team to make their badges using a badge maker (including adaptations to ensure all students could have a go at pulling the badge lever to create their own badge). In the second half of our workshop we introduced the students to some edu-tech robots, exploring their functionality, and what students liked about them.

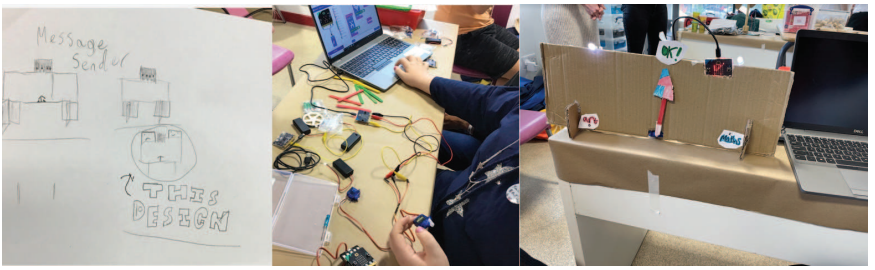
The second makerspace workshop involved two key components. Firstly, exploring and building skills using various elements and components that could be used to make simple robotic systems. The Maker{Futures} team set up a range of Skill Builder stations for the students to learn basic skills in cardboard construction for prototyping including using cardboard cutters, joining techniques and electronics. Secondly, using this new knowledge and skill, students set about to imagine and design their own trustworthy robotic systems. The aim was for the whole research group to create 3 or 4 new robot or system 'prototypes'. We asked a series of questions to get our ideas flowing. These were questions about what our robots will do, how we might control them and what systems, technology or materials might support this.

In our third workshop, the students worked together to realise their designs. Using the Maker{Cycle} (Maker{Futures}, 2020) they took an iterative approach, working through the stages of look, think, make and test. The Maker{Futures} team was on hand to support the student co-researchers. Our analysis centres from our four student groups produced prototypes detailed below. These prototypes are also materialised and brought to life in our project animation (link). Together, these serve as illustrative examples of the power of disabled

young people asserting themselves as designers and makers and centre the importance of co-production with a critical disability studies lens in mind.

MESSAGE SENDER

TEAM: Blue Katsuki & Blue Bunny



A cardboard messaging device with two coloured sides which read 'Art' in pink and 'Maths' in blue. A multicoloured arrow made from a wooden craft stick acts as a pointer and two white LED s. An electronic Micro:bit has been coded to react to inputs of sound and buttons. These in turn send an electronic message to a mini servo that converts it to mechanical movement to drive the pointer. The team demonstrated their prototype by Blue Katsuki asking "What is your favourite subject?" To which Blue Bunny responded with a non-verbal clap. The pointer moved to Art. The student showcase explained how this could be integrated or developed into further communication such as on mobiles or apps, selling its potential to the rest of the group.

ROBOTIC TEA TRAY

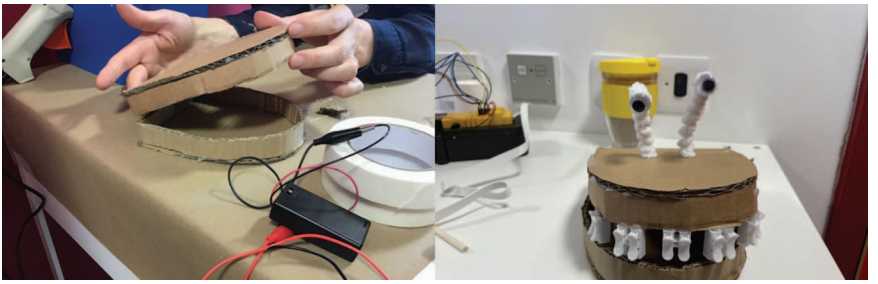
TEAM: E*, Golb Tesla, Cod Fish**

The Robotic Tea Tray was built upon one of the robots (Dash) that was particularly accessible for one student researcher who is a wheelchair user with limited mobility and speech. Utilising the robot's iPad touch screen interface, the team wanted to utilise this existing function and developed

a cardboard tray system that was built on top of the existing robot. To test their prototype, the team used paper cups and soon realised there was an issue with stability when stopping as all the cups toppled over. They used an iterative approach to try a range of solutions to overcome this problem. The latest prototype included a stabilisation leg that helped prevent the tray tipping forward.

CHOMPY

TEAM: Felix Moth



Felix Moth had a vision for a talking therapy-bot in the shape of a mouth that asked a set of open ended questions (like a therapist). He started by making a 3D mouth shape from cardboard and hot glue and thought the small white plastic wire connectors looked like teeth, so added these to the model. Although he had originally planned to use a circuit board such as the Micro:bit or MakeyMakey to programme the speaking element of the design, his prototype took a more playful turn. Using a small motor and offset weight, we created a source of vibration that he fitted inside the mouth. When switched on, the teeth wobbled across the workbench and the teeth 'chattered'. He added googly eyes on pipe cleaner stalks and the prototype developed a personality. Felix Moth named it Chompy.

FAN

TEAM: Goku Blue

One student worked with their teaching assistant to make an electrical fan. At the start of the day, we had gone on a search for a fan for our workshop room given the constraints of the room and the lack of ventilation. Geku Blue used this problem as an opportunity. He explored the electronic components in the *Maker Emporium* and tinkered with an electric motor and batteries. Some problem solving strategies were needed when they encountered problems with their early prototypes. Blue Geku and his teacher tinkered with various possibilities to see what would work and was able to overcome these issues.

Data collection involved a series of visual, textual and ethnographic data collected and collated by the lead author in close collaboration and agreement with the broader team. Analysis was collaborative, happening within the workshops themselves and within the follow up interdisciplinary team meetings where key moments and themes were discussed, addressed and findings collectively agreed upon (Cornish et al., 2014). We do however recognise the limitations of the students not being present in these lead meetings which hinders the truly collaborative analysis process. We will now turn to our reflections of the makerspace process and what we believe this demonstrates in terms of the alignments between critical disability studies, co-production and makerspace philosophies and methodologies. To do this, we focus on three key dimensions. First, we discuss capacity building and interdependencies. Second, we explore the affirmative cultures of collaboration and third, we showcase play, possibility and preparing for prototypes. Together, these work to showcase disabled young people as researchers, designers and significantly, makers.

Capacity Building and Interdependencies

Disabled young people can and should be involved in the research, design and making of technology. As participatory researchers, our project has this commitment. Disabled children and young people shape research and bring their own imaginations, ideas and agendas to the table (Carter & Coyne, 2018). As part of an emphasis on trust and agenda setting, we want to start with the important foundations of capacity building, interdependencies and cultures of collaboration. These are crucial to co-production, critical disability studies and creating the environment for makerspaces and Maker{Spirits} to thrive. Co-production approaches seek to illuminate collaboration, diverse knowledge and how the process of power redistribution and learning from

research participation facilitates capacities of researcher skills (Durose et al., 2012). For critical disability studies, disability is deliberately positioned as an opportunity, as aspirational and as centred on ability and possibility (Goodley, 2024; McRuer, 2006; Kafer, 2013). Makerspace philosophies and manifestos that develop a Maker{Spirit} (Kay & Buxton, 2024) seek to emphasise active participation in the doing, valuing the learning journey of making and recognising how we have creativity within us all. The practices within our project and specifically our makerspace workshops played with all of these philosophies and processes.

Our first example which demonstrates this interrelationship is our commitment to researcher relationships and capacity building in the team. In our first makerspace workshop, we took some time to get to know each other, share our names, share something that we had made that we were proud of, and, if comfortable, share something we find difficult and might occasionally need help with. This activity emphasises how we all have strengths or skills and areas in which we need support, thus flattening hierarchies of knowledge, skills and confidence. This also aligns with critical pedagogies which sees educators and facilitators as learning alongside students. This activity also did a significant act in centralising and celebrating the things that might not work, the things we can't do or indeed, the things we fail at. This is reflective of a makerspace approach, where a cyclical, iterative approach helps the maker actively expect things to fail to help build understanding and how what we do next can improve what we make. This in turn gives us confidence to take risks and try something new without fear. In the queer art of failure, Halberstam (2011) highlights that a failure to live up to normative societal expectations on productivity can allow for more creative ways of knowing and being within the world and pushes us away from individualised ways of being into collective models of interdependency. Our co-produced and makerspace practice sought to flatten and make ordinary the iterative process of learning, creating and collaboration.

The second activity that we want to reflect upon as telling of capacity building, interdependency and collaboration is our preliminary work on research badge making. Our badge making meant that our student co-researchers could talk creatively about ideas they had for their pseudonym and we took time to work on these together. The ethics of identification and research ownership is significant and becomes evermore important when working with those who may be on the margins or misappropriated within research. Naming, attribution and pseudonyms are ethically significant and carry with them representations of who and what matters within research relationships (Pinter & Zandian, 2012). Whilst striving to allow our

co-researchers to self define, we were faced with ethical navigations related to safeguarding our young people which meant that not all our student co-researchers could be identified. To ensure no one remained singled out, we worked to assemble ourselves as a *collective*. Our activity of badge making had a dual purpose. First, naming our co-researchers and its crucial role within critical disability studies' politics and co-production. And second, the making of badges themselves built up to, and scaffolded, makerspaces and Maker{Spirits} (Kay & Buxton, 2024). The badges themselves were a material manifestation of co-production with disabled young people and them making their mark as a research team.

Image description: A circle of badges made by our student co-researchers. A central badge includes the Maker{Futures} logo.

Our third example that seeks at centering capacity building and relationalities is our starting point of what our Maker{Futures} team termed our 'Robots Rules':

> Respect each others contributions
> Our ideas are all relevant so be brave and creative
> Be sensitive and listen to each other. We learn from each other
> Our questions make us into better makers so ask away
> Teamwork makes the dreamwork – let's help each other
> Say if something is difficult. We all need help sometimes.

Our robot rules sought to establish a culture, shared values and ways of working as a research team and as a makerspace collective. These robot rules align with participatory research methods, co-production and disability research that celebrates diverse ways of knowing and being (Liddiard et al., 2024). Such methods may include assembling shared agreements on participation, collaboration and 'can promote respectful integration of ideas' (Olsen & Carter, 2016: 7). Our 'Robots Rules' not only set a collective agenda, but captured the spirit of teamwork, diverse contributions and crucially, celebrated interdependence. 'Robots Rules' are particularly valuable as affirmative and capacity focused right from the outset, position disabled young people as active, competent and reflexive makers. Importantly for us, they align makerspaces with principles of co-production and disability research. However, we also want to say that this was a practice that was already well embedded within the culture of the students and the school. Much of the work and collaboration by our student co-researchers was done so carefully and intimately captured access and inclusion. This has resonance with disability theorist Mia Mingus' (2011) careful reflections on 'Access Intimacy':

> Access intimacy is that elusive, hard to describe feeling when someone else "gets" your access needs. It is not dependent on someone having a political understanding of disability, ableism or access. Access intimacy is also the intimacy [felt] when other disabled and sick people who have an automatic understanding of access needs out of shared similar lived experience [and the] different ways ableism manifests … [There is a shared kind] of access intimacy that is ground-level, with no need for explanations.

Further to this access intimacy found within our coming together to name our team and assemble our robots rules, such sensitivities of inclusion also came to being through the cultures of collaboration. These were demonstrated in waiting, stopping, responding and meeting the team wherever they needed to be.

Cultures of Collaboration

One example of such access intimacy within the maker process itself was when a team member had to be absent for care or medication purposes, the rest of the team downed tools and the design process simply *stopped* until they could

continue together as a team. There was an integration of waiting, delaying and slower time, in line with crip theory and crip time (Kafer, 2013; Liddiard et al., 2022). This very practice also spoke to the disability ethos of 'Nothing About Us Without Us' (Charlton, 1998). The team was irrefutable in being a unit and this only served to strengthen the design process. Two of our other student co-researchers worked on designing a messaging device. Developing this idea came from thinking through technology that might help our student co-researchers' family, friends and peers and school. In particular, they were interested in creating a design for those who may be Deaf or non-verbal. Making and creating more specifically also felt, to us, like a key way of centring participatory research methods, relational work and interdependencies. This aligns with makerspace philosophies that centre seeking solutions to real world problems (Tabarés & Boni 2023) and that by having a personal connection to a problem relevant to their communities increases participation (Barton 2016).

One of our teams centred one particular students' high level skill of touch based control using an iPad interface to control the tea tray delivery service robot. By centering this student, ideas developed around how they could incorporate such a system into their design. This in turn opened up possibilities around expertise and inclusion. In this case, disability was the driving force of inquiry (Goodley, 2024). Making was done as a response to access and inclusion but centred, celebrated and significantly, made it fun. Similarly, our student co-researcher, *Goku Blue*, who created the fan, made his prototype as a response to a need and making the space in which we were all making, accessible. Whilst our methods for co-production and makerspaces scaffolded and sought to centre care and a celebration of capacity, it became very clear that our disabled young people were the real team leaders and experts in this. An example of this was during our makerspace workshops, the school fire alarm went off. What could have been a stressful and disruptive encounter became a noticeable point in which we as the academic and maker leads felt care and leadership from the students themselves. As 'outsiders' to the school, students took it upon themselves to take control and responsibility of the group and lead the way for us to safely exit the building. This was a moment that stuck with the academic team, revealing the flattening out of power and a reminder that together, everyone played their part in caring for each other. In this moment, we were not the leaders nor the authority – the students were and we should not underestimate that. Building upon this ethos and creation of culture, we now turn to the importance of play, possibility thinking and the preparation for co-creation. We want to stress that following the foundations created that set agendas, a state of play, possibility and prototypes can come to be.

Play, Possibility and Prototypes

In our previous section, we sought to demonstrate that our young co-researchers are makers of technology and important collaborators. They are not consultants nor are they solely end users, they are active creators and teenagers with their own interests, desires and aspirations. From discussions of hairdressing and makeup through to technologies to enhance play as a fellow boxing competitor or dance teacher, ideas of assistive technology were broad, varied and not restricted to medicalised or 'assistive' devices often assumed in disability design discourse. Many of these were for fun and 'just because'. Greenstein (2014) advocates for playful and imaginative activity as a starting point for alternative ways of being, resetting power relations and authentic engagement. For Greenstein (2014: 81), 'playful methodology is positioned simultaneously within a certain social reality while posing an alternative to it, and opens spaces where binaries and hierarchies can be examined, challenged and blurred. This position is conducive for researchers who seek to overcome disabling social barriers and educational exclusion': our makerspaces sought to align with this. Technology entered the conversation here when social exclusion happened and society was not playing its part. In these contexts, technology became an opportunity to be assistive in teenagers' everyday lives. Conversations around our students' priorities set the agenda for not only the research process, but what and how they chose to design as a community. We want to stress that crucial to our process and indeed the Maker{Cycle} (look, think, make, test) (Maker{Futures}, 2020) is a commitment to *play* and *possibility*.

In starting with the maker, possibility thinking and asking 'what if' is at its core (Craft, 2000, 2002). What makerspaces and methods of co-production have in common is a commitment to open-endedness, which leaves a space for, in our case, disabled young people to explore and to create based on their own ideas and agendas. Our research and design process sought to give permission to play, explore, have fun and to follow interests. As Dougherty (2012: 12) notes, 'makers are enthusiasts … they enjoy a level of interconnectedness … they belong together, connected by a common passion'. What is significant around creativity, play and exploration is that space and freedom is given to expansiveness and autonomy which, in turn, leads to a confidence and a competency in working with others (Montouri, 2008) and designs having the space to then emerge. One of our examples shows this.

Felix Moth had a number of design ideas based around robots and a therapy bot, developing through exploring materials available (Colvert et al., 2024; Rowsell et al., 2024), including a box of white sprung wire connectors he thought

looked like teeth. *Felix Moth* began to put materials together and start realising a prototype. Using the Maker{Cycle} (Maker{Futures}, 2020) he iteratively looked at the materials available and thought about the role they could have in his design. The Maker{Futures} team suggested that the pair of teeth could be made to 'chatter' with the help of a motor and an offset weight. As *Felix Moth's* therapy bot developed, his focus shifted from a more medicalised, therapeutic and rehabilitative tool, to one of playfulness and fun. The therapy bot became 'Chompy' as eyes on springs were added that wobbled as the chattering teeth shuffled and 'chatted' across the worktop. *Felix Moth*, began our initial workshop expressing that one of the things he found challenging was group work and he would prefer to work alone. He had begun sketching initial design ideas by himself but quickly developed confidence in his drawings and began to approach groups and ask them if they needed a designer. This demonstrates the value of such work in capacity building, recognising skills and what each team member can offer in the process of making and co-production.

Conclusion: Disabled Young People as Researchers, Designers and Makers

In this paper, we have demonstrated how disabled young people can and should be involved in all research and design. The rigorous methodologies of makerspaces and co-production philosophies and practice could not be separated from the research processes of participatory design and co-production. Our young co-researchers demonstrated that they are makers of technology and important collaborators. What they made with makerspaces all had others in mind, demonstrating a positive culture of difference, care and community. Our co-researchers positively influenced design philosophy in both what they made but also in how they worked together. As Goodley et al. (2021: p.13) note, 'The makespace is but another place through which to probe the possibilities of interdependence … disabled people are the inventors, makers, designers and end-users of new technologies as revealed in emancipatory, participatory and co-production approaches to disability research.' Our empirical work evidences this to be the case.

The fan for our room, Chompy, the tea tray and the communicating messaging tool all had others in mind. The prototypes were manifestations of the positive culture of difference and care felt and how the community of our co-researchers positively influenced the philosophy of design. Our student co-researchers were in tune with each other, with the academic team, the community, their

family, and their friends. Accommodating each other's needs, waiting for team members, and looking out for each other were part of the process and exemplified through Makerspaces. This collective working, culture, knowledge, and empathy with and for each other should be central to technological design and, of course, central to disability research and co-production. More than this, the products came to be as a response to student priorities of what to design. Again, this reminds us not to solely think purely about assistive devices and design, but community, play and joy. It is also not solely about novel creations, but the learning, the communication and the work with others teaching and supporting each other that makes makerspaces important.

This paper offers a series of contributions. We offer a novel contribution to makerspaces literature that recognises the Maker{Spirit} as an *embodied* one, with diverse bodies and minds leading the way and opening up possibilities of inquiry. By introducing critical disability studies into conversation with makerspaces, we want to showcase the contribution of disability being the driving force of inquiry for research, design and creation (Goodley, 2024). This offers scholars and practitioners within makerspaces to rethink with disability as a key driver for design and co-creation. This is inclusive of a collaborative process that builds community, supports one another in failure (Halberstam, 2011) and inevitably, crip making and creation. All of which are further affirmative possibilities brought about by makerspaces practices and methodologies that critical disability studies can further embed in their participatory methodologies. Disabled young people should be centred as research designers, collaborators and makers, with this work offering extensions to contributions on co-production with young people (Carter & Coyne, 2018; Liddiard et al., 2019). Access needs to be embedded from the outset, not as an afterthought nor as positioning disabled young people as consultants or 'end users' of technologies not in their imaginaries. Designers of future technologies should start with the community, their needs, desires, aspirations and their interests. Our message to those working in the field of autonomous systems and technological design more generally is that our disabled young co-researchers have the skills and capacities to really give technology a rethink and importantly, a *remake*.

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