voxUp

Co-Developing a Music Technology for Beatbox Looping in a Special Education Needs Setting

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Abstract

Dominant techno-futurist narratives in education foreground AI, automation and optimisation, casting technological progress as a pathway to efficiency and measurable improvement. This article examines an alternative, relational techno-future through the development of voxUp, a custom beatbox looper designed with and for a UK special education (SEN) school. Rather than pursuing automation or standardisation, the project explores how accessible music technologies can support creative agency and shared authorship through real-time, embodied sound-making. Methodologically, the study draws on observations of classroom sessions, educator interviews, and co-design workshops, conducted through institutional mediation, to move towards a working prototype of an adaptive, multi-channel looping interface.

Guided by critical disability technoscience and science and technology studies, the analysis identifies five interconnected themes: (1) socio-technical landscapes of music-making within SEN settings; (2) sensory–motor attunement and embodied timing; (3) accessibility frictions and barriers to sustained use; (4) creative ownership and micro-agency; and (5) relational atmospheres and shared attention. Together, these themes show how music technology mediated forms of sensory reciprocity and emergent agency, enabling inclusive participation in musical experimentation.

The design process demonstrates the value of slow, locally embedded, knowing-making over market-driven EdTech imaginaries. By resisting the prevailing AI-centred paradigm, voxUp offers a situated, care-based counter-narrative to dominant educational techno-futures, illustrating how assistive music technologies can be made customisable, repairable and responsive to diverse bodyminds.

The article contributes to debates on culturally specific techno-futures by showing how creative, disability-informed design practices in non-profit educational contexts can reconfigure participation and challenge normative assumptions about ability, authorship and technological design progress.

Keywords

music technology, special education, participatory design, looping, disability studies, techno-futures, accessibility

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1. Introduction

Adapting to the ubiquitous use of emergent technologies such as AI and automation presents a challenge. As these complex technologies become more sophisticated there is a risk that they become less human-centred. In a more technological, posthuman future, there is an urgent need to question dominant socio-technical systems and neoliberal narratives. These prevailing techno-futures are influencing the development of new technologies by eroding human agency and catering only to normative standards. One area where this is of particularly pertinence is in special educational needs (SEN) settings. This research focusses on technologies used to access musical expression within an SEN setting by exploring these issues through classroom observations, interviews and co-design development of a beatbox looper device. This paper explores a human-centred approach to technology in education - focusing on developing music technology that is more inclusive and user-friendly. To propose an alternative techno-future this study asks:

1. Why, where, when, and how is music technology - in this case used for looping - currently used in practice within SEN education?
2. How can participatory and socio-technical approaches in SEN contexts inform the co-development of accessible looping technologies, and what features are valued by practitioners?
3. How can technology promote agency? What opportunities and challenges do accessible looping technologies present for imagining alternative educational techno-futures?

This study considers these questions in relation to several theoretical lenses including Human-Centred Design, Disability Studies, and Situated Action. Relating these theories to a tangible technology development our analysis asks not only what the technology does, but how it reframes agency, voice, and collaboration for learners often excluded from dominant technology development narratives.

1.1 Contemporary Technological Societies

In contemporary societies, technology is frequently positioned as a driver of progress with development often tied to capitalist, consumer-based logics (Vrečko Ilc 2024) of economic growth, automation, and optimisation that privilege particular visions of the future (Goodley 2024). This results in homogenous, mass-produced tools designed for a broad, neurotypical and non-disabled customer base, with limited attention to care, relationality, or localised needs (Egilson and Jónasdóttir 2023; Whittaker et al 2019) or technology that offers expression in a 'musicky' fashion by ensuring that input from users is scaled and conformed to 'acceptable' output (Gouzouasis and Bakan 2011). Such socio-technical systems prioritise standardisation over adaptability, which limit the creative possibilities

for disabled users and the practitioners who support them (Förster and Schnell 2024). The neoliberal influence on these types of technology development has contributed to "growth-lock-ins" (Cantner and Vannuccini 2017; Robinson, 2020). Consequently, these technologies can lack flexibility, accessibility, and local relevance which sidelines the needs of learners who do not fit standardised pathways (Zubairi et al. 2021). Issues with the current neoliberal socio-technical system are especially evident in the SEN sector, where the tools available are shaped by both state-led curriculum requirements and the commercial imperatives of EdTech markets. These technologies for disabled students are frequently framed in deficit terms, aimed at "fixing" or "overcoming" difference rather than valuing diverse modes of expression (Bialka et al. 2024) with accessibility often detrimentally 'bolted-on' at the end of developments rather than embedded from the outset (Foley and Ferri 2012).

1.2 Human-Centered Techno-Futures

Against this backdrop, human-centred and participatory approaches to technology design offer a critical counterpoint and fertile grounds for co-creating technology that responds to local contexts and lived realities (Hsueh et al. 2023). These approaches foreground the situated, relational, and embodied dimensions of technology use, framing disabled people not as passive recipients but as co-creators of tools and futures (Hamraie and Fritsch 2019). This section explores how technology can be shaped by and with the people who use it, embracing alternative futures grounded in care, creativity, and local meaning.

1.3 Critical Disability Technoscience

We draw on several lenses within this research. Participatory design provides methods of incorporating the voice of the users into a co-design process. Critical disability technoscience is described by Hamraie and Fritsch (2019) as politicised practices of non-compliant knowing-making, where knowing is inseparable from making as a situated, material practice in which knowledge is produced through making and doing (Haraway 2016; Hamraie 2017). These knowing-making practices work within and around systems of power, privilege, and oppression through frictional access practices, rejecting access-as-retrofitting in favour of access-as-transformation – help us to think of tools that adapt to the body rather than forcing bodies to adapt to them. Situated Action (Suchman 1999), allows us to think of the contextual nature of the use of technology where emergent and context-specific improvisation is inseparable from the physical, social, and material environment in which it occurs. Haraway's (2016) cyborg and kinship frameworks prompt us to consider music technology as part of an interconnected human–nonhuman assemblage, made and remade through relationships and shared practice. Haraway's notion of kinship offers a way of imagining music-making

relationships beyond transactional or efficiency-driven frames, instead seeing them as collaborative, entangled, and sustained through care. This resonates with Ginsburg and Rapp's (2024) argument that disability is not solely biological or medical, but is continually shaped by social, cultural, and historical contexts. Such perspectives challenge the dominant "fixing" or "overcoming" narratives, instead foregrounding the value of co-constructed futures in which disabled people, and their allies actively shape the conditions of creative participation. New structures of knowledge and belonging are generated through anthropologies of care.

Imagining alternative techno-futures means stepping outside the dominant logics of efficiency, standardisation, and deficit framing to ask what kinds of technologies could emerge if they were grounded first in the lived realities of learners and practitioner/facilitators. As educators and students repurpose tools, adapt interfaces, and hack together methods to create meaningful musical participation, these grassroots innovations are legitimate sites of design knowledge. Technology can be seen as not a fixed product, but as an evolving, relational process - one that resists being "rolled out" uniformly and instead grows with the needs, desires, abilities, contextualised use and cultures of its users.

1.4 Accessible Digital Musical Instruments (ADMIs)

Accessible Digital Musical Instruments (ADMIs) emerged from the intersection of disability, performance, music technology, and research – developing across a broad range of maker cultures and drawing on input from disabled musicians and artists and their collaborators, practitioners and students within SEN schools, academic researchers, and engineers of music technology. These types of technologies are set within a backdrop that questions traditional measures of musical skill, shifting focus from precision and formal measurement systems to improvisation, sonic exploration, and emotional engagement (Frid 2019).

Many early examples of ADMIs were developed through disabled performers hacking systems together, research labs creating bespoke devices or augmenting off-the-shelf technology or combining technologies, or DIY maker spaces allowing for spaces/equipment to make. These ADMIs existing as stand-alone instruments which are either modified instruments or completely new creations or using accessible technologies to create access. These instruments often draw on cross-disciplinary expertise, combining hardware hacking, software design, and user-centred methodologies to create instruments that are responsive to individual needs and local contexts (Förster/Schnell 2024). Over time, this blend of grassroots tinkering and structured research has helped ADMIs evolve from one-off prototypes into more widely recognised tools for inclusive music-making. One of the most successful tools in this arena is the Soundbeam. Developed in the late 1980s, the Soundbeam uses ultrasonic sensors to translate movement into MIDI, enabling music-making without physical contact. Widely adopted in SEN schools, it allows even small gestures to trigger sound, making it valuable for those with

limited mobility. While it remains a benchmark for accessible music technology, it is expensive and requires technical expertise to use illustrating both the potential and constraints of long-standing ADMIs.

Use of open-source platforms like Arduino and Bela boards has been critical to pushing the field beyond off-the-shelf assistive tools. Research projects exemplified in conferences such as NIME (New Interfaces for Musical Expression), through organisations like Drake Music, The One-Handed Musical Instrument (OHMI) Trust, and bespoke commissions for individual disabled musicians have provided fertile ground for developing ADMIs. Projects like the Kellycaster (Harrison et al. 2019) demonstrate user-centred iterative design with underpinning themes of embodied tech, user agency, and anti-standardisation.

1.4.1 Developing New Accessible Digital Music Technologies

Drawing on reviews of ADMIs (Frid 2019; Ward et al. 2019) and the work carried out around their design considerations (Ward et al. 2017), ADMIs within a SEN context require several key considerations:

1. **Customisability** — interfaces should be adaptable to a range of motor, sensory, and cognitive abilities, allowing for personalised configurations that evolve over time.
2. **Low entry, high ceiling** — instruments must enable immediate engagement for novice users while supporting deeper exploration as skills and confidence develop.
3. **Multimodal feedback** — incorporating visual, tactile, and auditory cues to support different sensory needs.
4. **Contextual fit** — instruments must work within the social, physical, and cultural environment of SEN classrooms, integrating with existing practices and resources.
5. **Co-design processes** — involving disabled musicians, educators, and therapists from the earliest stages to ensure that instruments are grounded in lived experience.

ADMIs do not exist in isolation, they form part of a broader ecosystem of co-agent technologies distributed between human and non-human actors. Design is inseparable from the relationships and contexts in which the technology is embedded. The complex design, development, and integrations of ADMIs are highlighted in figure 1 by the work of Förster and Schnell (2024).

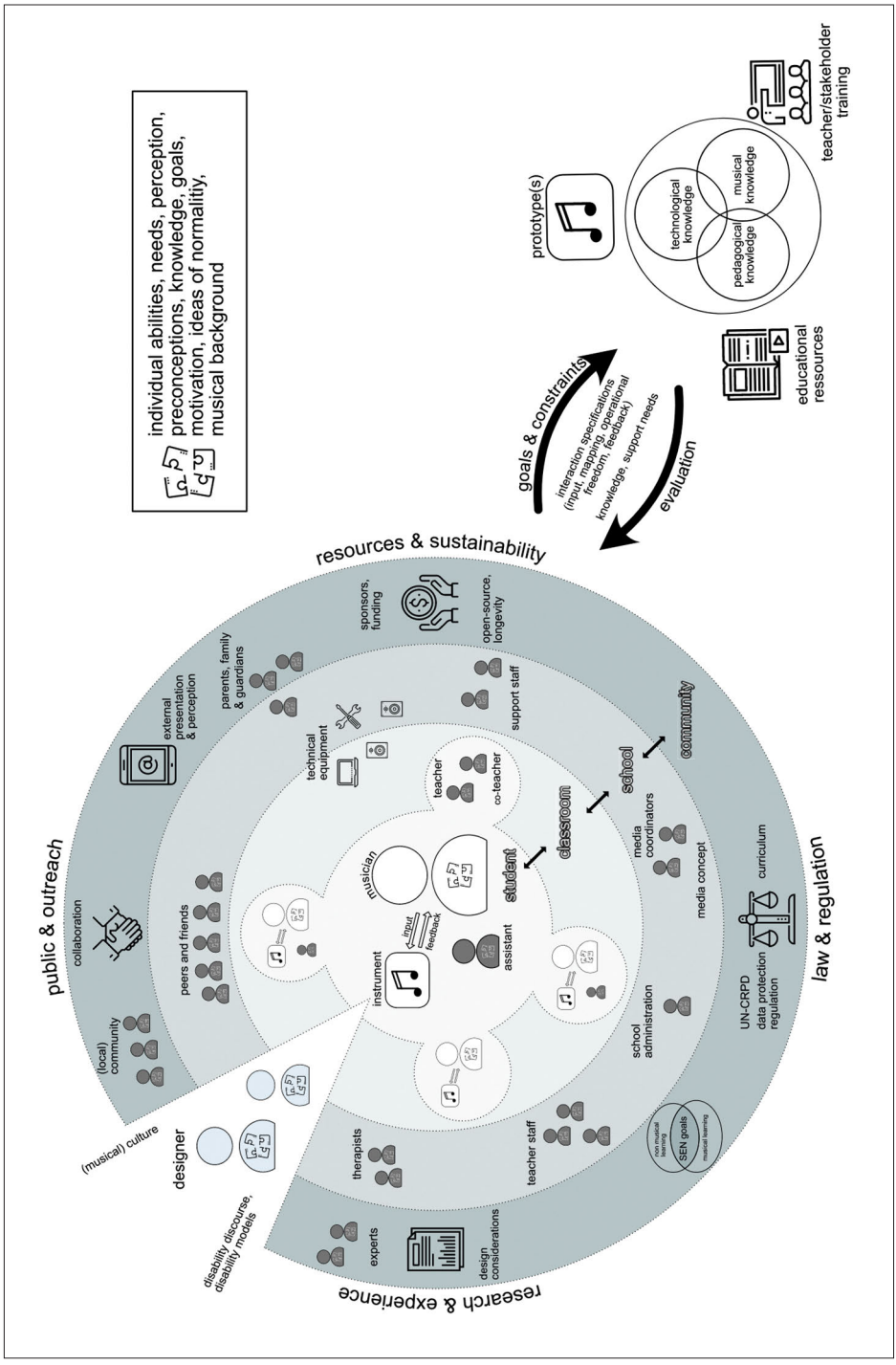

Figure 1: Socio-technical ecosystem of ADMIs (Förster and Schnell 2024)

In music-making, ADMIs are not simply assistive tools but catalysts for new relational practices. When co-developed with users, they can become vehicles for improvisation, collaboration, and joy, challenging the deficit-based framing that dominates mainstream EdTech and aligning with the care and creativity centred futures proposed in this paper. The Cake Index (Asnani 2025) offers an alternative metaphor for reflective, care-based evaluation. Each "layer" of the cake represents a level of change on individual, relational, systemic layers, prompting questions such as: Who helped bake this? Who set the temperature? Who didn't get a slice? What flavours of change emerged – care, curiosity, solidarity? These prompts invite honest, humane reflection that shifts evaluation from extraction ("tell us your story") to reciprocity ("what did we learn together?").

1.5 Beatboxing for speech and language therapy

Beatboxing originated within 1970s Black hip-hop culture in New York as an emancipatory, low-resource artform grounded in community, rhythm, and resistance (Chang 2005; Krims 2000; Schloss 2004). Its use of the mouth, breath, and vocal tract to create complex rhythmic patterns emerged as a creative response to material constraints (Schloss 2004), functioning as a form of self-expression and collective world-making in the face of structural injustice (Rose 1994; Chang 2005). Acknowledging these roots situates beatboxing not merely as a therapeutic or educational tool, but as a historically situated practice of self-definition and empowerment. In this project, bringing beatboxing into SEN classrooms therefore carries not just instrumental value for speech and language work, but also cultural and political significance.

This project uses beatboxing as a mechanism to frame a usage scenario with the looper. Beatboxing provides an engaging and socially interactive way of conducting speech and language exercises (Moors et al. 2020). Beatboxing has demonstrated direct and measurable benefits for adults with intellectual disabilities (Icht 2019; Icht/Carl 2023); as a promising tool in the rehabilitation of laryngectomees (Moors et al. 2020) and used within music therapy for those with Disorders of Consciousness (Murtaugh et al. 2024). Beatboxing can be described as a pluralistic and democratic artform (Best 2021), where corporeal sound-making is inherently considered meaningful and expressive (Joyce 2024).

1.6 Human-Centred and Co-Design Approaches

This research draws on Human-Centred Design (HCD) approaches in placing the needs, abilities, and experiences of humans at the core of the design process (Norman 2013; IDEO 2015). Drawing from participatory and user-centred traditions, HCD employs iterative cycles of observation, ideation, prototyping, and evaluation, empowering users as co-producers of a technology's form and function rather than passive recipients (Norman 2010). In educational and assistive tech-

nology contexts, HCD has proven effective in creating tools that are accessible, functional, and empowering for diverse user groups (Newell/Gregor 2000). HCD also addresses wider cultural and societal concerns by embedding diverse lived and embodied knowledge into the design process from the outset to support more equitable socio-technical futures. This is particularly important in contexts where technology intersects with inclusion, accessibility, and creative expression. Co-design extends this HCD ethos by involving users as active partners in shaping functionality, form, and interaction (Sanders/Stappers 2008). Rather than treating participants merely as sources of insight, co-design enables their experiential expertise to directly guide development. In educational and assistive contexts, this can mean that students and educators are central to defining how tools operate and integrate into practice. In this study, HCD and co-design principles informed the development of a bespoke looper for classroom use. This allows the development of the technology to be grounded in authentic use-cases, shaped by user priorities, and refined through collaborative prototyping. The resulting approach aimed to produce a device responsive to diverse physical abilities, pedagogical needs, and the practical realities of teaching within SEN settings. This contributes to the broader discourse about how participatory design can foster inclusion within creative and assistive technologies.

2. Methodology

This study employed a mixed-methods approach, combining qualitative observation and interview data with structured co-design activities to inform the development of an accessible looper prototype for use in a SEN school setting. The methodology was guided by a Human-Centred Design (HCD) ethos and combines classroom observations, participant interviews, and a co-design workshop.

2.1 Participants

The two participants of this research are both central users of the technology – a beatboxer and a music technologist. Both are specialist practitioners and contributed to the front-end exploratory co-design process:

1. Dean Yhnell (DY), A beatboxer who has personally experienced Tourette's, OCD and ADHD. Dean teaches beatboxing and has worked in SEN school contexts for over ten years.
2. Mike Whitlock (MT), A music technologist with over fifteen years' experience embedded within an SEN school.

Purposeful sampling (Creswell 2013) has been used to gain participants, this was criterion based in that the stakeholders have an interest in using, have used, or do use music technology. The selection of MT was opportunistic in that they

were known to the first author through previous research projects. Both brought extensive practical expertise in adapting music technology for diverse learning and accessibility needs. Both participants provided informed consent to be part of the project. The scale of participation was intentionally small, prioritising depth and contextual knowledge over breadth.

Observing the technology in use was carried out in line with school safeguarding protocols. Students were attending ongoing beatboxing sessions (that far predated this research) as part of their regular routine. No data was collected about the students participating in the sessions.

2.2 Researcher Positionality and Reflexivity

In this front-end development phase, our engagement was intentionally mediated through two specialist practitioners rather than through direct design work with students. Safeguarding requirements and the exploratory scope of the research meant that this stage focused on understanding existing practices and constraints rather than undertaking participatory co-design. The beatboxer (DY), whose experiences of Tourette's, ADHD and OCD inform his pedagogical and creative approaches, and the music technologist with long-term experience in SEN classrooms, provided situated expertise and a grounded entry point into the socio-technical landscape of looping in the school.

As researchers who do not share the lived experiences of the intended users, we recognise that the knowledge generated here is mediated by these relationships, reflecting the perspectives of these practitioners and our own interpretive position. Practitioner accounts are valuable for mapping context, but they do not substitute for student perspectives. This dynamic reflects wider challenges around proxy representation noted in participatory research (Parsons et al. 2023) and the risks of treating "voice" as inclusion without shifting influence (Ymous 2020).

Institutional terms such as impairment or complex needs reproduce official educational language rather than the authors' own framing. We recognise the exclusions and hierarchies such terminology can encode and include it here only when necessary for institutional accuracy.

Positioning the work in this way aligns with our techno-futures orientation. Early design ideas inevitably emerge from those involved at this stage, and this phase is understood as preparatory groundwork rather than a complete co-design process. Future stages of voxUp will expand participation as the prototype matures and appropriate pathways for involvement become available. Where possible, future design and development will be led by young people with lived experience of disability as co-researchers and co-authors, extending the project's commitment to relational design and shared epistemic authority.

2.3 Front-End ADMI Design Process

This research focuses on the co-design activities during the front-end design process. In terms of the development project, this uses a series of HCD activities to iteratively explore the use of loopers within SEN. This process was managed by the research team, with participants MT and DY invited to contribute, feedback, and review at any point. The development activities are mapped out in figure 2. To ensure that the evolving design remains grounded in user needs and authentic practice, a series of co-design activities were conducted with MT and DY.

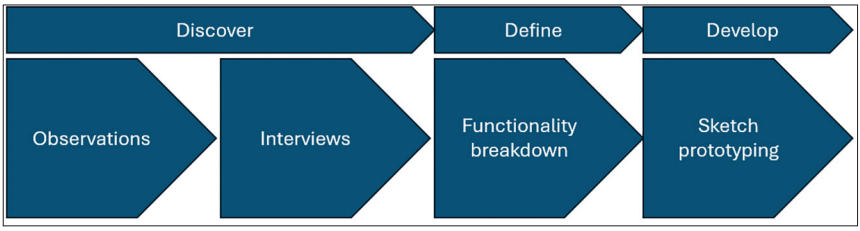

Figure 2: HCD activities conducted in collaboration with MT and DY.

2.3.1 SEN Classroom Observations

Two observation days were conducted in the SEN school. Each involving multiple 20–30-minute live beatboxing sessions with participants (MT and DY) using existing looper technology – a Boss RC-505 looper device. Observations generated detailed field notes on interaction patterns, accessibility challenges, and teaching adaptations.

2.3.2 Practitioner Interviews and Thematic Analysis

DY and MT each participated in one-hour semi-structured interviews with DY participating in a further interview around lived experience. Interviews focused on their current practice using loopers in SEN education. audio recordings of the interviews were transcribed. Interview transcripts were initially imported into browser based qualitative coding software Ligre and coded using inductive thematic analysis following Braun and Clarke's (2006) methodology. Iterative manual coding was conducted by the two authors, grouping data into emergent themes, and refining them through repeated engagement with the dataset. The final five overarching themes capture key considerations for the co-development process.

2.3.3 Co-design Workshop – Functionality Breakdown

A Likert-scale activity was used to elicit structured feedback on feature priorities. The benchmark Boss RC-505 looper device was separated into 10 categories of functions and participants were asked to rate potential features such as effects, number of channels, and control interface within the defined functional catego-

ries. The scale ranged from 1 (representing the simplest possible configuration, such as a single-button loop pedal with no effects) to 9 (representing a fully featured Boss RC-505). This exercise facilitated targeted discussion, supported comparison across a broad range of possibilities, and ensured that the prototype's design balanced aspirational and pragmatic considerations.

2.3.4 Co-design Workshop – Sketch Prototyping

Sketch prototyping using a 1:1 scale physical mock up. Participants were asked to evaluate a selection of buttons, switches and controls to aid user interface development. MT and DY also provided feedback on the initial basic functioning electronic hardware and software prototype. Comments and feedback were captured in the form of research notes and photographs of interactions with the prototypes to provide insights into design direction.

2.4 Techno-future Multilevel Perspective Analysis

To analyse the current technology within the context of the SEN education landscape multilevel perspective (MLP) analysis was used (Geels 2002) to allow the current situation to be explored in relation to the socio-technical and SEN specific regimes. This allows assessment of the innovation using data from multiple perspectives as well considering tensions between these perspectives. This is particularly useful to this research in designing and developing a novel ADMI technology.

3. Results

The following sections map out DY and MT's situated practice followed by the front-end co-design developments.

3.1 Dean Yhnell - Lived Experience as Disability Knowledge

Dean's account of Tourette's, ADHD, OCD and early stammering reframes beatboxing not as a neutral pedagogical tool but as a form of embodied disability knowledge shaping how he teaches and designs sessions. Rather than treating disability as background context, he links his sensory and cognitive patterns directly to the ways he reads, responds to, and designs for students in SEN settings. This provides a disability-informed counterpoint to more medicalised institutional framings circulating in the school environment.

As a child, Dean remembers compulsions, repeating phrases, tactile rituals and tics long before he had diagnostic language. Looking back, he describes these as "always in me... before I had even the Tourette's [diagnosis]," foregrounding how his understanding begins with lived experience rather than clinical description. Beatboxing entered this landscape as an intuitive form of self-regulation

and sensory expression. In adolescence he began to notice how rhythmic patterns shifted his impulses: "My late teens… my realisation was like: damn, my beatboxing has made the Tourette's disappear a bit. I was becoming more aware of it. I think it's the beatboxing that's helping me maintain the control."

Experimenting with "little triplets" when tics resurfaced, he found they "just subsided." Rhythm became a cognitive and sensory scaffold, redirecting impulses rather than suppressing them. This aligns with critical disability technosciences' emphasis on working with bodily difference through creative, non-compliant adaptation rather than correction.

This embodied sensitivity informs Dean's pedagogy. He describes "reading" energy shifts and sensory thresholds, recognising behaviours that seek stimulation or signal overwhelm: "I can read it… I can feel when people have it." Lessons are paced "short and sharp… until you've got the trust," with activities broken into small, achievable challenges. Decisions about positioning ("side-by-side"), gaze ("looking at something that's not looking back"), and the use of "side missions" are informed by his awareness of how he manages sensory and cognitive intensity during the music-making process.

Dean's reflections on technology highlight accessibility as felt rather than merely functional. Portability, ruggedness, tactile feedback and immediacy matter because they reduce friction and support emotional safety: "For ADHD, especially… being able to rapidly get ideas down, not faff around." He also acknowledges the pressure of institutional agendas, being brought in to "tick boxes" or fulfil inclusion quotas, while resisting "smash and grab" work in favour of continuity, trust and relationship.

Taken together, Dean's account foregrounds disability not as deficit but as a rich field of expertise that informs inclusive design. His practice exemplifies non-compliant knowing-making within institutional constraints and adds an explicitly disabled practitioner perspective to a project otherwise reliant on intermediaries. At the same time, his story does not replace the need for disabled students' own perspectives; rather, it highlights the importance of future stages of voxUp embedding disability-led authorship more directly in design and evaluation.

3.2 Beatboxing in Context – Observed Session Analysis

The researchers took field notes at several beatboxing sessions held on two separate days within an SEN school. These sessions were conducted with a beatboxer (situated in Wales) over Zoom and MT in the music room at the SEN school alongside the music technologist as a facilitator. Observations of the participants facilitating beatboxing classes and discussing the technology with the music technologist formed the data for this part of the research. Insight into how existing technology was used informed the design of a new looper system tailored for this setting. Figure 3 shows the setup involved at the SEN school and table 1 shows the different technological components that formed the setup.

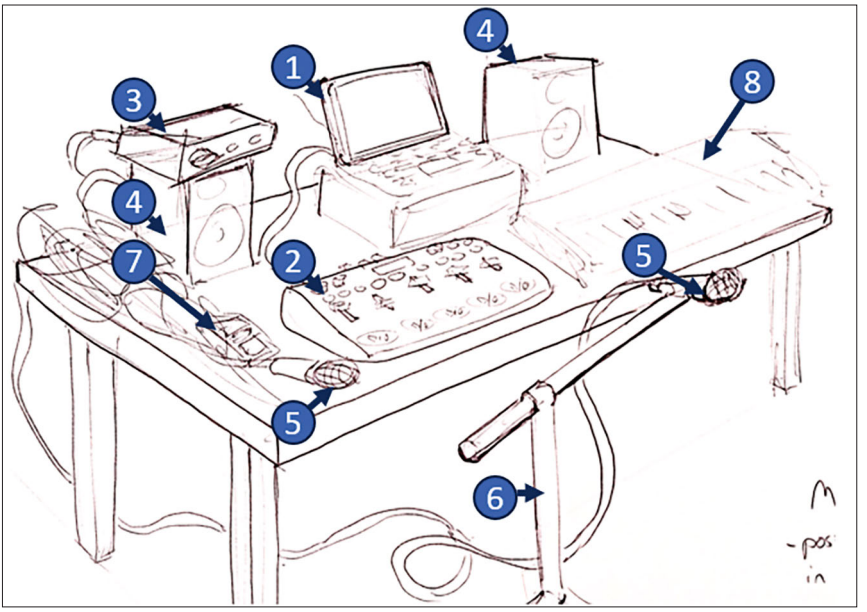

Figure 3: Beatbox session via Zoom setup

	Equipment List			
No.	**Description**	**Model**	**Usage**	**Criticality**
1	Laptop	Macbook	enabled Beatboxer via Zoom also as an input and editing	1
2	Looper	Boss RC-505 Loop Station	5 channel looper. With inbuilt track effects and	1
3	Audio Interface	Focusrite Scarlett 2i2	Pre-amp for the mics	1
4	2xspeakers		Loud with significant bass	1
5	2x Microphones	Standard mics with pop guard	Mics were on stands and positioned for wheelchair users	1
6	2x Mic stands		Positioned to the side of the students	2
7	Effects unit (input)	Kaossilator	Provided additional effect during sessions	2
8	Keyboard (input)		not observed being used.	2

Table 1: Equipment within beatboxing with looper over Zoom session

Table 2 describes the range of activities and details of observed sessions run by MT and DY at the SEN school. This includes levels of engagement as well as any connections to therapeutic outcomes.

Category	Range Observed	Notes / Examples
Session length	20–30 minutes	Multiple short sessions run back-to-back; minimal break between.
Activities observed	Vocal sound practice (humming, clopping, "Ka" sound), beatboxing with looper, Clop Tennis game, favourite words exercise, jam sessions, effects use, equipment troubleshooting	Activities tailored to each student; mix of technical skill-building, games, and performance.
Therapeutic style activities observed	Speech and language therapy (breath control, annunciation, muscle building), rhythm work, confidence building, support with eating (reported outcome)	Therapy aims embedded in musical activity rather than as separate exercises
Number of people in session	1–2 students per session	Space was wheelchair accessible
Student-led activities	Personal best challenges (e.g., 40 clops), talk of home looper practice, student-selected words, troubleshooting own equipment	Encouraged autonomy within session flow
Method of operation of device	Looper and microphones, sometimes student's own looper device	MT adjusted gain and access; DY operated remotely via Zoom.
Set-up time	Short turnover between sessions; adjustments made on the fly	Included mic positioning, gain/amplitude tweaks for quieter students, cable routing
Accessibility facilitation	Mic height adjustments for wheelchair users, increased gain for quiet voices, remote facilitation via Zoom – adjusting Zoom settings for musician	MT's role was critical in adapting equipment per student needs

Table 2: Activities and equipment used during sessions

The second visit combined observation with informal feedback from MT regarding recurring challenges and opportunities in the sessions. MT was shown initial design ideas to illicit feedback regarding form factors and aesthetics; this led to further discussion of core features and functionality. This feedback was also captured in field notes and provided a clearer understanding of user requirements to ensure ease of activation, clarity of visual feedback, minimal setup time, and flexibility for a range of musical exercises. Taken together, these observations and conversations generated a set of user needs for voxUp. Practitioners prioritised accessible hardware layouts that accommodate wheelchair users and those with limited dexterity, intuitive controls with clear visual and tactile feedback, robust construction for frequent handling, and core looping and effects functions that respond quickly in live use. They also stressed the importance of educational fit (supporting teaching aims and varied activities), straightforward connectivity to existing equipment, and practical considerations such as cleaning, maintenance and safe cable management in busy classrooms. Benchmark analysis was conducted of off-the-shelf technology that offers some of the functionality required. This external search grounded the design requirements in current available technology and real-world dynamics of music-making in a SEN school setting, rather than in abstract technical considerations alone.

3.2.1 Institutional Language

During the observations and subsequent interviews, the language used within the setting occasionally draws on diagnostic or institutional terminology, this reflects the everyday vernacular of SEN education in the UK rather than an intention to categorise or medicalise. In presenting these accounts, we retain their original phrasing to preserve the authenticity of voice and context, but we also recognise the ableist histories embedded in such language. Our analysis therefore reads these statements critically, situating them within a broader move toward disability-led and relational understandings of difference. We therefore treat these accounts not as objective statements about disability, but as windows into the institutional and cultural conditions that shape music-making in SEN settings.

3.3 Educators Interviews Thematic Analysis

The analysis generated five interrelated themes that describe how accessible music-making unfolded within the socio-technical, sensory and relational conditions of the classrooms: (1) socio-technical landscapes of music-making within SEN settings; (2) sensory–motor attunement and embodied timing; (3) accessibility frictions and barriers to sustained use; (4) creative ownership and micro-agency; and (5) relational atmospheres and shared attention.

3.3.1 Theme 1: Socio-technical Landscapes of Music-making in SEN Settings

Participants described music-making as a hybrid ecosystem of accessible tools (e.g. Soundbeam, Cosmo switches), professional music equipment (e.g. loopers, Kaossilator, DAWs), and improvised adaptations connecting the two. Devices acquired through grants, fundraising or charity support were gradually assembled into personalised setups tailored to each class or student. MT emphasised that this involved layering technologies together in context rather than using them in isolation: "we had the sounds coming from Logic on the switches and then a couple of students were playing little things on those switches and then looping them into the looper." (MT) These assemblages depended on local expertise and relationships as much as on the technology itself. The resulting socio-technical landscape was fragile: funding cycles, broken equipment or staff turnover could easily render tools unusable or "lost in the cupboard." Facilitators became the connective tissue, maintaining these networks of devices, people, and support systems. This theme shows how music technology in SEN settings are less of a fixed toolkit than a constantly reconfigured assemblage, echoing cyborg and Critical disability technosciences' perspectives in which accessible practice emerges from ongoing human–machine collaboration rather than from any single device.

3.3.2 Theme 2: Sensory-motor Attunement and Embodied Timing

Practitioners consistently described the importance of reading students' sensory and motor cues, changes in pacing, gesture, posture, or vocalisation, as indicators of readiness, overwhelm or interest. These micro-signals shaped how sessions unfolded. Rather than following a fixed plan, facilitators adapted activity length, volume, tempo and level of challenge in response to these shifts.MT explained that this often meant adjusting the musical structure to match a student's internal rhythm: "Sometimes the timing they needed wasn't the timing we'd planned so we'd slow things down or loop something longer until it felt right for them." This responsiveness cultivated forms of shared regulation of pace and intensity, letting the musical structure meet the student's internal rhythm. Such relational adjustments helped sustain presence in the activity without sliding into overwhelm or disconnection. Practitioners also emphasised that small preparatory actions such as moving closer or further away, adjusting lighting, or simplifying the sound palette could make the difference between a student joining in or disconnecting. These adaptations were not framed as "fixing" sensory difference but as creating the conditions for safe participation (Ginsburg/Rapp 2024). Taken together, this theme shows how music-making in SEN settings relies on continuous sensory–motor negotiation, where timing is co-produced between student and facilitator. This aligns with situated and relational theories of action, emphasising that accessibility emerges through moment-to-moment attunement rather than through static design features alone.

3.3.3 Theme 3: Accessibility Frictions and Barriers to Sustained Use

Alongside moments of creative engagement, practitioners described a range of frictions that limited the sustained use of accessible music technologies. These barriers were not inherent to the students but arose within the wider socio-technical systems of SEN classrooms, shaping what was possible *for* them. Equipment often required specialist knowledge, particular cables or software updates, meaning that tools could easily become unusable if a staff member left, a wire broke, or if setup time was limited. As DY put it, "It's a brilliant bit of kit, but if the one person who knows how to get it going isn't in, it just stays in the cupboard."

Devices obtained through grants or inherited from previous staff sometimes no longer worked with current systems or arrived without compatible chargers or documentation. Practitioners also noted that complex interfaces or multi-menu systems could slow down sessions or interrupt moments of flow, leading them to default to simpler tools even if more advanced devices had greater potential. Accessibility was therefore experienced not only at the level of physical interaction, but in the practicalities of maintenance, time, staff knowledge and institutional priorities. These barriers influenced which technologies became embedded in everyday practice and which remained aspirational. This theme foregrounds the importance of designing tools that reduce setup friction and support continuity, aligning with STS accounts of technological adoption as dependent on local expertise, care work and infrastructural stability.

3.3.4 Theme 4: Creative Ownership and Micro-agency

Across the sessions, moments of creative ownership, however small, played a central role in sustaining engagement and supporting participation. Facilitators emphasised that agency often appeared in micro-gestures: selecting a sound, triggering a loop, choosing when to join or withdraw, or shaping the timing of an interaction. These small decisions were meaningful forms of authorship, particularly in classrooms structured by routine, adult direction and tightly scaffolded activities.

DY noted that giving students a discrete musical "entry point" often created space for their own ideas to emerge: "When they get that one sound that's 'theirs', they start steering it and they decide when it comes in, and you can see them take ownership of the moment." He described these actions not as compliance but as signals of preference, curiosity or experimentation.

Facilitators also highlighted the importance of leaving space for unexpected contributions and sounds that were off-beat, out of time or not anticipated within the activity design. Rather than correcting these moments, they often became the basis for joint play or new musical directions. These improvisational shifts allowed students to shape the aesthetic trajectory of the session, even briefly, reinforcing the students' role as co-creators rather than recipients of instruction.

This theme illustrates how accessible music-making can create openings for micro-agency that resist deficit-based narratives about capability. It aligns with

disability studies accounts of agency as relational, emergent and distributed, enacted through subtle forms of decision-making and co-production rather than in the individualising logics of autonomy, competence or control. Virtuosity then in these cases can be seen as always relative to the individual.

3.3.5 Theme 5: Relational Atmospheres and Shared Attention

Practitioners described the atmosphere of the room with its emotional tone, sensory environment and interpersonal dynamics as central to how students engaged with music-making. Rather than locating participation solely in individual ability, facilitators emphasised that shared attention emerged through co-presence, gentle pacing and varying the pressure of forms of interaction tailored to the individuals' responses. These relational conditions often mattered as much as the tools themselves.

One strategy involved orienting students and facilitators side-by-side, focusing together on a shared object such as the loop station or screen. DY reflected that this reduced the intensity of direct gaze and created a calmer shared focus: "When we're both looking at something that isn't looking back, they seem to settle and it gives us something to meet around." Such arrangements supported students for whom direct face-to-face interaction was not the most comfortable or accessible mode, offering alternative ways into communication. Facilitators also highlighted the importance of celebrating small moments and brief sounds, gestures or eye movements that signalled connection. These moments were amplified through positive feedback, humour or gentle imitation, building momentum without escalating pressure. The participants spoke of relational warmth and predictability helping students feel safe enough to experiment, withdraw and re-enter the activity on their own terms.

This theme underscores that participation in music-making is co-produced: not simply a function of individual intention, but of the affective and relational atmosphere in which activity unfolds. It aligns with disability studies perspectives on interdependence and co-regulation, emphasising that inclusion is generated collectively rather than delivered to individual students.

3.4 Co-Design Workshop Results

The co-design workshop took place at Arts University Bournemouth as a front-end exploration of the requirements for voxUp - a looper ADMI. Activities were structured to deep dive into areas identified during the earlier classroom observations and interviews. The aim was to collaboratively define the required functionality and form of the voxUp device, using the critical functionality of the Boss RC-505 as a benchmark.

3.4.1 Session 1: Functionality Benchmarking

The RC-505 benchmark device was broken down into ten functional categories, which were discussed in turn and compared against a "minimum functional product." Participants then assigned a value on a 1–9 scale, where **1** represented the simplest possible functionality (or not required) and **9** matched the full functionality of the RC-505. This process also facilitated discussion of technology trade-offs and prioritisation. The results of this exercise are displayed in figure 4.

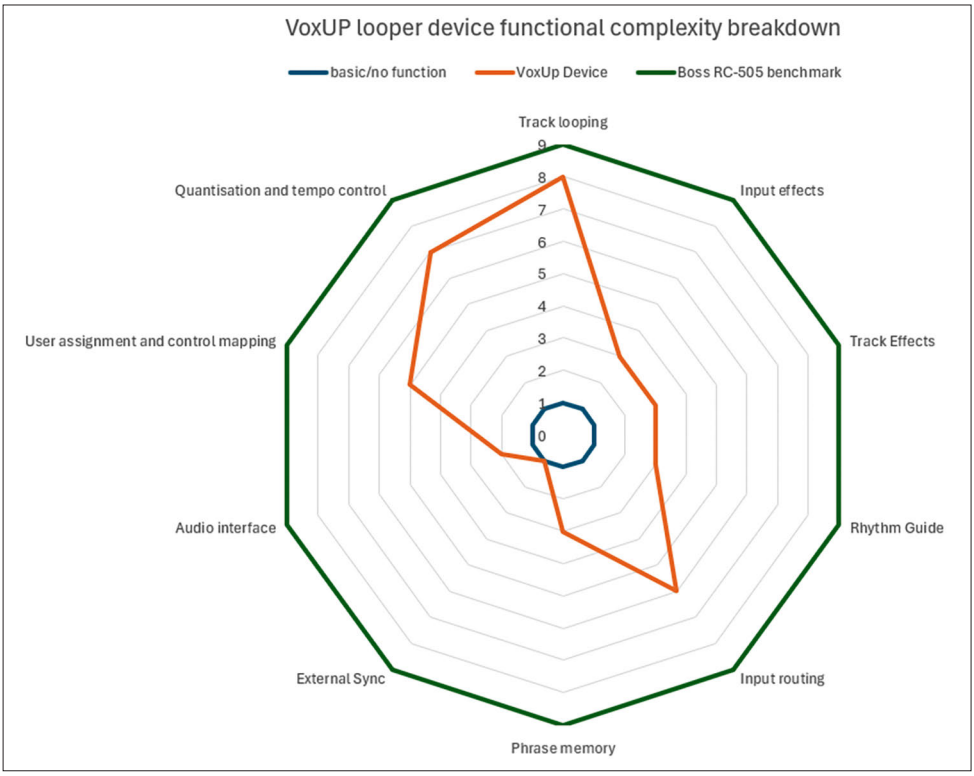

Figure 4: diagram visualising the required functional complexity of the SEN educational voxUp device

Each functional category was explored in turn with DY to elicit what was important to have and how that might work in a future speculated design. Figure 4 visualises the required functionality of voxUp as mapped between the basic prototype and the Boss RC-505. Overall, participants agreed that voxUp should retain the core strengths of the RC-505, multi-track looping, a small set of meaningful input and track effects, a simple rhythm guide and reliable microphone inputs while significantly simplifying its interface. Advanced studio functions such as complex phrase memory, external synchronisation and audio interface features were deemed unnecessary for classroom use. Instead, practitioners prioritised switch-adaptable

control mapping, clear visual feedback and quantised looping to support quick, satisfying results. They also emphasised portability, a more inviting physical form, and reduced menu complexity so that non-specialists could set up and use the device without extensive training. Scenario mapping and functional scoring confirmed the importance of a smaller, more focused feature set than the RC-505, prioritising accessibility, core looping and effects, and clear, engaging feedback over professional-level studio functions.

3.4.2 Session 2: Sketch Prototyping

Building on Session 1's findings, participants worked on physical sketch prototyping (Isa/Liem 2021). Participants described their ideal dimensions and approximate shape of the voxUp looper. This allowed a sketch prototype as shown in figure 5 to be made and then assess during the workshop. In discussion with DY and MT, comments and drawings were made on the prototype to capture feedback. Controls were attached to allow participants to explore and provide further feedback on the voxUp device's dimensions, formfactor and interface layout.

- **Size and form** – The RC-505 was considered a reasonable reference point for size; however, participants suggested a more angled top surface to improve visibility and ease of use.
- **Button/fader tactility** – Large, clearly tactile buttons emphasised as important for accessibility. Smooth fader emphasised for ease of speedy interaction.
- **Dial/knob styles** – Clicking mechanisms to allow selections and change range and amount of effects
- **On/off switch placement** – Positioning should prevent accidental activation while remaining accessible.
- **Port locations** - Ports should be front-accessible for ease of connection, but with protection to prevent accidental damage.

The workshop also trialled a minimal working prototype of the electronic hardware and software which could loop a single channel with two effects. DY and MT provided feedback on the length of time needed for using the tracks as well as how difficult it is to synch tracks without quantisation. This minimal prototype promoted a rich discussion of various features and how they work together as a functioning system.

Figure 5: Co-exploring the physical layout of voxUp

4. Discussion

The in-depth research conducted in partnership with practitioners MT and DY revealed the factors at play within the technological landscape. The prototyping and empathy driven design activities frame the ADMI development within the context of this landscape and the individual users of looper technology. The observations, interviews and co-design workshop conducted in this project are foundational to the development of a novel ADMI. The findings illustrate how inclusive design emerges not only from technical adaptation but from relational, sensory, and experiential forms of expertise that disabled practitioners like Dean bring to the pedagogical encounter. His story demonstrates that the principles of critical disability technoscience as non-compliant knowing-making, situated improvisation, and relational access are already being enacted in classroom practice. Taken together, these findings show how relational, sensory, and socio-technical practices within SEN classrooms can function as lived forms of participatory and critical disability technoscience, grounding the theoretical framing in the everyday work of practitioners and students. As Spiel (2024) argues, accessible technology design is always a situated, relational process shaped through humility, response-ability, and ongoing negotiation rather than attempts at solutionist fixes.

4.1 Multilevel Perspective Analysis

This development sat within the complex socio-technical ecosystem as mapped out in figure 6 which included locally driven bottom-up regimes (green) competing with top-down regimes (blue) with many of the regimes sitting in tension with one-another. Developments must seek to address both sides of the regime spectrum to be meaningful and acceptable but also work within their systems of use. By exposing these constraints and tensions, important links between outside–in and inside–out perspectives can be explored as opportunities to push system innovation (Geels 2005). Dean's reflections on being brought in to "tick boxes" highlight how institutional framings of neurodiversity and creativity can drift toward tokenism, even when well intentioned. Integrating disability-led knowledge into design processes therefore also requires structural shifts: valuing continuity, relational depth, and co-authorship over extractive or quota-driven intervention.

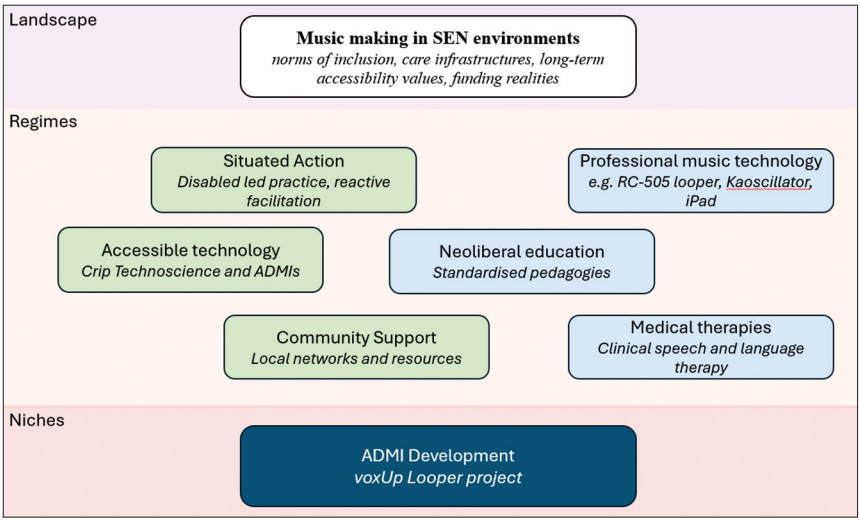

Figure 6: MLP analysis of socio-technical elements within ADMI development

4.2 Current Looper Technology

Within sessions, music-making operated as both a creative outlet and a means of building relationships, confidence, and expressive agency. In line with Dronkert's (2023) notion of "cripping collaboration," these interactions did not merely include disabled bodies within normative metrics of success but reshaped what "success" might mean in this context. Here, performance was valued not in terms of what might traditionally be perceived as technical mastery, but in terms of connection, experimentation, and enjoyment and mastery relative to the individual. Such an approach positions creative tools not as endpoints in a skill-development pathway, but as companions in open-ended exploration. This resonates with Hamraie

and Fritsch's (2019) framing of critical disability technoscience, where disabled-led practices generate slow, care-based technologies with culturally grounded uses as a counter to techno-hegemonic logic that privileges speed, novelty, and optimisation over social connection and lived experience. The Boss RC-505, as used in observed sessions, is a respected professional tool, but in our context, it became a site of negotiation rather than straightforward adoption. Its complexity prompted practitioners and researchers to collaboratively decide which features mattered, in which situations, and for whom. This was less about stripping the device back than about reassembling it into a technology assemblage that could be made, attended to, and remade in response to educational and access needs. Here, access is framed not as retrofitting functionality, but as transformation (Hsueh et al. 2023) – a process in which the design itself is reshaped to accommodate and celebrate diverse modes of engagement. In doing so, we aim to shift the conversation from what devices *can* do toward what the users *want* them to do in the pursuit of equitable creative futures. This reflects what Williams (2023) describes as the infrastructural politics of access work, in which technologies can either reinforce normative expectations or open up space for divergent, disability-led ways of being.

In this space, access was understood as a frictional practice (Hsueh et al. 2023) something negotiated. Participants engaged with the device's tactility, responsiveness, and capacity to invite experimentation, transforming it from a studio-bound performance tool into an adaptable, convivial instruments (Lucas et al. 2025) embedded in classroom rhythms. Decisions about inclusion or exclusion of features such as favouring fewer, more meaningful effects, or adding switch-enabled ports to connect with existing assistive ecosystems became acts of design politics. Dean's lived experience offers an example of what Hamraie and Fritsch (2019) describe as critical disability technosciences' knowledge-making that reworks normative technologies through embodied intelligence, sensory attunement, and frictional access practices. Rather than treating disability as a set of functional limitations to be mitigated, his approach foregrounds disability as method and an interpretive and creative lens that shapes how technology is used, adapted, and shared.

4.3 Negotiating Agency Toward an Accessible Techno-future

voxUp aligns with the principles of convivial tools (Lucas et al 2025) and critical disability technoscience (Hamraie/Fritsch 2019), privileging care, longevity, and situated practice over market expansion. While this approach resists the extractive cycles of capitalist innovation, it also complicates traditional return on investment arguments, making such designs less attractive to producers of professional music technology. In this sense, voxUp exemplifies an alternative innovation trajectory – one that invests in social, cultural, and pedagogical value rather than monetary profit. Viewed through the lens of critical disability technoscience (Hamraie/

Fritsch 2019), such choices resist the market drive toward ever-greater complexity and rapid feature churn. Instead, the looper was conceived as an adaptable, stable, and open-ended tool, supporting ongoing tinkering and reconfiguration in real-world educational contexts. This aligns with Lucas et al.'s (2025) vision of convivial tools that empower users to shape their own practice and affirms that slowing down design processes can create technologies that enable, care, and include, rather than accelerate and exclude.

Following Asnani (2025), participatory equivalence emphasises that inclusion is not achieved by making everyone participate in the same way, but by ensuring that diverse ways of taking part carry equal value and meaning. People should be able to engage in activities they care about in ways that work for them, and those ways must be recognised as equally legitimate. In voxUp, this principle guided design choices that privileged agency and creative ownership over normative measures of ability or performance, reframing accessibility as mutual adaptation rather than retrofitted compliance.

Dean's story also highlights a central tension within inclusive music technology: our practices remain entangled in normative systems of value, even as we attempt to resist them. While Dean describes beatboxing as helping him "control" or "get rid of" his tics, this desire is shaped within a world that penalises visible difference and rewards "passing" as non-disabled. Similarly, practitioners and schools often celebrate students "improved" speech or increased verbal output, even when such goals reflect normative expectations of communication rather than perhaps the students' own preferred modes. Critical disability technoscience can be provocative precisely because it exposes this contradiction: interventions intended to support young people can unintentionally reinforce the very standards they struggle against. The question becomes not simply how technology enables children to enter the normative world, but how practitioners and institutions might shift toward adapting environments to be more inclusive with expectations and relational practices honouring difference rather than correcting it. As with debates between vegan and meat-eating ethics, there is no neutral position; every pedagogical choice carries assumptions about what types of communication and embodiment are desirable. Acknowledging this entanglement allows us to move toward more ethical, reflexive, and disability-led forms of design.

4.4 Evaluation and Impact

Conventional evaluation frameworks in educational technology frequently measure reach rather than relationship, counting attendance instead of accounting for change – or measuring change using ableist and heterogenic evaluation tools. These tools can miss changes that are relative and matter to the individual. Dean's emphasis on confidence, joy, micro-achievements and relational momentum also reframes what "impact" might mean in music technology contexts. These forms of change are not easily captured by standardised evaluation metrics but align

closely with relational and care-based approaches such as the Cake Index (Asnani 2025). Applying this ethos to voxUp positions impact not as measurable output but as co-created transformation sustained through care and shared authorship. Deans' emphasis on pacing, positioning, side-by-side engagement, and "small victories" directly aligns with the principle of participatory equivalence: ensuring that different ways of engaging are recognised as equally meaningful, rather than measured against normative expectations of communication or performance. What the models is, is not compensatory inclusion but adaptive relational practice.

4.5 Front-end Design Outcomes

This front-end phase is the first step in a longer process and embodies the project's commitment to slow, situated making, where technological form emerges from sustained collaboration and the lived contexts of diverse users. Such work stands in contrast to move-fast-and-break-things models, recognising that accessibility, care, and cultural grounding require time to build an understanding of the full context in which technologies are deployed.

Mapping out the user needs, functional requirements and sketch prototyping provides the basis for a responsible product development that is grounded in care. Breaking the interface down into ten discrete functional categories during the co-design workshop created a shared vocabulary between researcher and practitioner. This process facilitated not only technical prioritisation but also a "third space" for dialogue, where pedagogical needs, technical affordances, and creative aspirations could be openly weighed.

This informs the next development phase by ensuring a sensitive balance between social factors, functional priorities, and ergonomic considerations are embedded in the design considering the MLP.

5. Conclusion

The development of voxUp in this project represents an initial stage in the creation of a customised looper interface, moving from concept through collaborative specification to a basic proof-of-concept prototype (a single-channel looper with two effects). While intentionally minimal, this prototype demonstrated the technical feasibility of the co-designed features and provided a tangible focal point for discussions around functionality, accessibility, and creative practice. In keeping with the slow, care-based ethos of the project, this stage prioritised depth of engagement over speed of delivery, recognising that participatory work in educational and disability contexts benefits from time to build trust, test ideas, and refine collaboratively. This relationship is ongoing.

Situated at the intersection of cultural and media studies, disability studies, and creative technology, this research foregrounds embodied, socially co-constructed

technological futures that prioritise user creativity, autonomy, and accessibility over the dominant logics of speed, novelty, and market churn. In doing so, it contributes to critical debates in Disability and Critical Studies in Education by showing how accessible music technology can be developed within non-profit educational settings as a counter-narrative to neoliberal and ableist design paradigms. voxUp is a development situated in care relationships, supporting agency rather than conformity and modelling a small-scale, local, sensorially rich counter-narrative to dominant techno-futures. voxUp was designed to integrate with the existing systems and practices of the school, allowing different voices to be heard in whatever way the person at the centre wishes to communicate, and enabling on-the-fly adjustments in response to sensory, relational, and pedagogical needs. This design is wary of the entrapment of becoming a "disability dongle" (Jackson et al. 2022): one-off, novelty solutions created without disabled people and rarely embedded in the contexts they claim to serve. Instead of producing such fixes, we can as Sum et al. argue leverage technical expertise to make assistive devices more affordable, more customisable for diverse bodyminds, and more repairable by individuals encouraging methodological innovation by questioning the premise of developments framed as for social good, foregrounding care, situated practice, and local relevance (2024).

Following Hsueh et al. (2023), access here is understood not as a static compliance measure but as an ongoing, frictional practice, an aesthetic and transformative process rather than a retrofitted function. This reframing invites a broader shift in design discourse: from asking what devices can do toward asking what users want them to do in the pursuit of equitable creative futures. Ultimately, to bake equitable techno-futures we must ask not only who attends, but who feels seen, not how many voices were heard, but whose recipes shaped the mix. Only through such reflexive, care-centred participation can technological design move from access toward belonging.

5.1 Future work and limitations

The next phase will move from the current front-end phase into an ADMI device development of a multi-channel, classroom-ready looper that embodies the adaptability and design ethos described in this study. Dean's account underscores the need for future stages of the project to embed disability-led authorship not only in the interpretation of findings but in the design and evaluation of voxUp itself. His expertise highlights the limits of mediated participation in the current phase and points toward more sustained, collaborative forms of co-development. Future co-creation will extend to working directly with disabled students, embedding their authorship more explicitly in both design decisions and testing. These developments aim to strengthen voxUp as a tool that resists planned obsolescence, sustains care-based innovation, and functions as part of a longer-term shift toward equitable creative participation in educational settings.

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