The Slide-A-Phone: A Tactile Accessible Musical Instrument

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ABSTRACT
This paper details the design and development of the Slide-A-Phone, an Accessible Musical Instrument (AMI). The first author's spinal cord injury in 2004 hindered their ability to play traditional instruments, which motivated the development of the Slide-A-Phone. The Slide-A-Phone utilises tactile interfaces coupled with analogue and digital sensors to replicate the playability and expressive control of a saxophone, the instrument the first author used to play before the incident. The design process incorporated phenomenological perspectives and a blend of design methodologies, with the specific goal of fostering a robust musician-instrument relationship. We report insights into how personal experiences shape design and functionality, and the importance of accessible instruments in enabling creative practice and performance for individuals with limited functionality. We also describe the design and technical implementation of the Slide-A-Phone to evaluate the instrument's effectiveness and reflect on its potential to enhance musical engagement, social connections, cultural participation, and professional development.

Author Keywords
AMIs, Inclusive design, autobiographical design

1. INTRODUCTION
In this paper, we report the first author's lived experience as a disabled musician and the attempt to recuperate their lost relationship with a musical instrument. The recuperation started with a reflective process while revisiting recordings from 2002 to 2004, captured during weekly studio sessions of improvised music with fellow musicians. These recordings document a period before a spinal cord injury (SCI) in 2004 resulted in paralysis from the chest down, significantly impairing movement and motor function. This loss severely limited my[1] ability to play musical instruments as I once had, particularly affecting my hand movement and overall access to traditional instruments. In response to these challenges, I initially explored commercially available instruments and digital musical interfaces. While these explorations enabled some level of music-making and performance, they did not provide the same degree of creative freedom as previously experienced. This frustration catalysed the design of a bespoke Accessible Musical Instrument (AMI) with a tactile interface, driven by a desire to regain the agency, control, speed, and accuracy I once had when playing the saxophone.

The motivation to access better agency with an instrument led me to investigate how available technologies and resources could be leveraged to develop a custom instrument tailored to my physical capabilities. The design concept presented in this paper emerged from inquiries into how an instrument could foster a strong musician-instrument relationship through emulating pre-disability experiences, ensuring both usability and long-term engagement. Establishing this relationship has been critical, as it directly influences the effectiveness and sustainability of an instrument in practice [14, 18, 20, 23].

The resulting ADMI is the Slide-A-Phone, which combines the actions of a slide whistle or trombone with tactile interfaces that interact with analogue and digital sensors, outputting positional, touch, and breath pressure data in real time. Inspired by my experience as a saxophonist, I aimed to replicate the control of notes and tones through vertical movements, activating high and low tones. Due to my level of SCI, I cannot use tone holes or keypads, which require fine motor function.

To emulate, to some degree, the playing experience of the saxophone, the design aimed to incorporate similar characteristics and functions. These characteristics include shortening and lengthening a tube for pitch, controlling articulation, dynamics and tonal texture with breath and embouchure, and changing register with an independent key or button. Previous experiences performing with a slide whistle informed the concept of using a slide action for shortening and lengthening a tube. This became the central element of the design concept.

This paper offers the following contributions to NIME and AMI literature. First, by extending current knowledge around forming a design concept through understanding musician-instrument relationships from the phenomenological perspective of a disabled musician's lived experience [9, 13, 18, 30]. We share insights into developing ways of constructing meaningful input from a musician's experience, which informed and shaped the design and functionality of the object. Second, the introduction of a unique combination of methodologies into the design process adds to the existing frameworks for AMI and ADMI design [6, 12, 16, 19, 28]. We illustrate how the combination of design methodologies was integrated and coordinated throughout the development of the Slide-A-Phone. The rest of the paper is structured as follows. In the next section, we review the related literature on AMI and provide an overview of the methodologies. Sections 3 and 4 report the design process of the Slide-A-Phone and its technical implementation. Then, we evaluate its effectiveness against the research question and reflect on our results against current knowledge in AMI.

[1]. The first-person singular is used throughout this article to refer to the first author's design and creative practice associated with this project. This perspective aligns with autoethnographically documenting the lived experience throughout the design process.

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2. ACCESSIBLE INSTRUMENTS

Accessible Musical Instruments offer opportunities for people with limited range or functionality, and/or cognitive diversity to develop creative practice and perform music to a level that might otherwise not be possible. The Rhodes electric piano [5] and Roland Kirk's adapted saxophones [27], previously discussed [19] illustrate the tradition of innovation and adaptation in AMI design. Recent developments have integrated digital components into AMI, creating a new category of Accessible Digital musical instruments, or ADMI [6, 7]. Notable examples include introducing bespoke elements such as an adapted rotary knob cap [13], the 'Bishop Boom Box' - a physically accessible drum machine [16], and 'Strummi', a guitar-like ADMI [10]. In recent years, exploration of integrating haptic components to provide musicians with tactile feedback has been aimed at enhancing and expanding digital interfaces. This approach seeks to foster a more intimate and reciprocal relationship between a musician and their instrument or tool [2, 15, 24]

Additionally, access to musical instruments requires meaningful participation in music-making through opportunities for collaboration and performance. Engaging in musical activities has been widely associated with enhanced well-being, fostering social connections, cultural engagement, and educational and professional development [4, 25]. Expanding these opportunities through accessible instruments is essential for musicians seeking to develop their creative practices in community and professional settings, particularly across diverse disciplines. Organisations such as the One Hand Music Instruments Trust (OHMI)[2], Drake Music[3], Open Up Music[4], and Maupura Music Studios[5] have made significant strides in addressing accessibility to instruments and opportunities for collaboration and performance. Despite the existence of resources provided by organisations, accessing practical guidance and establishing connections remains a challenge for many individuals and their support networks [29]. Combinations of innovative design approaches and community-driven initiatives are crucial to overcoming these barriers and fostering inclusivity in musical participation.

3. METHODOLOGY

I conceived, designed, and developed the Slide-A-Phone predominantly using an auto-ethnographic process and autobiographic design methods [21, 22]. However, because of my disability, I needed assistance to undertake tasks that were impossible for me to complete. I specifically needed help with construction, soldering and the physical set-up of components and the prototype throughout testing and creative practice. Although there has been limited conceptual and design input from the assistant, we have had discussions where technical or construction issues have arisen. This collaborative approach is a common design practice in Accessible Musical Instrument (AMI) and Adaptive Digital Musical Instrument (ADMI) development, often called a participatory design framework [16, 26]. The ecologies that can be associated with human interaction with designing and evaluating ADMI throughout participatory methods are discussed by Lucas et al., [12, 13].

Drawing from my experiences as a musician before and after being disabled, I incorporated reflective practice, action research [17], and the *theatre of practice model* [1] to explore design concepts and develop the prototype based on constructive critical feedback on performance and progress. The theatre of practice is a model for understanding experiential learning and context through reflection in the creative process. The models' visual reference represents how creativity evolves in a theatre where people, environments, materials, and tools interact. It shows how experiences form development from the past to the present, and into future projects. Another way to view experiential learning in design as it progresses is to consider the instrument as a technological probe [8, 9, 11]. Through the iterative use of the prototype, issues were addressed, improvements were made, and achievements were integrated into the design.

The initial concept and subsequent design were guided by data and analysis obtained through standard and extended Occupational Therapy (OT) methods. Standard OT methods can be beneficial when assessing how mobility and functionality might match goals, cultural settings, and technologies in home, recreational, and work environments [3]. By integrating information from standard OT sessions with a qualified Occupational Therapist, with our extended/adapted OT methods, I was able to develop a better understanding of how my movement range and functionality could shape the design concept [19]. Augmenting, extending, or adapting OT methods allowed me to consider a range of materials, electronic analogue and digital sensors and technologies that could interact as elements within the instruments' design and construction. This approach aligns with disability-led and partnered methods of design, specifically, ability-based design practice [28].

4. DESIGN PROCESS

4.1 Analysis of recordings

The design concept emerged through reflecting on my performance experiences and recordings pre- and post-disability. I analysed three albums of recordings (two recordings from weekly studio sessions, and one a live performance recording) from before my disability, using them to examine my technique, creativity, and proficiency on the saxophone. These performances, originally 20 to 40 minutes long, were edited into 5 to 20-minute segments for each album at the time they were recorded. The recordings also prompted phenomenological reflections on my relationship with the instrument. Listening evoked memories of setting up the saxophone - its tactile feel, the energy required to play, its responsiveness, and how I engaged and interacted creatively with others. Journaling these reflections allowed me to compare recent experiences and post-disability recordings of playing an adapted guitar, a laptop-based DMI, voice, percussion, and slide whistle. Both sets of recordings were captured in free improvisation creative collaboration settings.

Using archival recordings for technical and comparative analysis, phenomenological reflection, and autoethnographic enquiry assisted in identifying key technical aspects, expressive qualities, and values to integrate into the instrument's design.

4.2 Findings of the recordings analysis

The analysis of the recordings revealed that pre-accident, I could express ideas and develop material using composed and improvised melodies, extended techniques, and sonic elements relatively unimpeded by physical restrictions. While able-bodied musicians may also encounter physical limitations and must navigate the affordances of their instruments, these challenges are considerably more pronounced for disabled musicians, given that standard instruments are designed with able-bodied users in mind. Free improvisation was a key part of my creative practice, requiring the ability to create material and interact with others spontaneously. Key observations from comparisons between

[2] https://www.ohmi.org.uk/instruments.html
[3] https://www.drakemusic.org/
[4] https://www.openupmusic.org/
[5] https://www.mapurastudios.org.nz/programmes/mapura-music/

pre- and post-disability included tactile feel, haptic control, and the physical and technical abilities enabling accuracy, speed, and expansion of ideas. I also examined differences in the connection between cognitive processes, embodiment, and physical-musical output. Documenting these technical attributes clarified what I felt was essential for a rewarding musician-instrument relationship and informed a table of observations that guided the design process.

Table 1. Technical and Experiential Qualities and Values

Field	Description
Skills Required	Accuracy
	Speed (between cognitive reaction, creativity, and action)
	Physical access and engagement
	Fluidity
	Flow
	Ability to create a range of pitch sets and tonal palettes
Connection and Communication	Access to the entire range of the instrument enables
	Unimpeded link between ideas and musical realisation
	Ability to react to ecological and environmental influences
	Navigation of negation of specificities (characteristics of the instrument or situation)

4.3 Integration with OT sessions

Whilst assessing the qualities and values, I also gathered data from standard OT sessions with an Occupational Therapist and extended OT methods I had developed [19] . The analysis of this data informed a better understanding of my unique limitations of movement and functionality. Combining knowledge gained from the movement/function analysis with the reflections of my playing experiences helped develop the concept behind the bespoke prototype. I was able to consider what shape the design might take, how it could function, the types of materials for its construction, and the range of sensors and interfaces that could work to integrate these elements. Though the interface aims to provide the user with the ability to play with accuracy and speed, the structure of the instrument needs to be simple enough for any support person to easily assist with set up for practice and performance. It is also important to consider how the instrument's ergonomics support playable actions that will not invoke fatigue. Information gathered from the range of movement was crucial in determining the dimensions of the initial design and how physical interfaces and sensors could be positioned.

4.4 Design requirements

The Slide-A-Phone was designed to incorporate tactile or haptic interfaces that respond in real time to digital or analogue sensors that translate movements into sonic output. The concept developed into a functional instrument design inspired by my experience with a slide whistle post-accident. The slide mechanism highlighted how the vertical movements required to play foster a sense of agency with the instrument. To emulate other functional characteristics of a saxophone, the instrument required a mechanism to control ADSR envelopes via a breath controller for tonal dynamics and a sensor to facilitate register changes.

Another requirement was to mount interface components to ensure physical accessibility and ease of play. Given the iterative prototyping process, widely available, cost-effective, off-the-shelf materials were used to enable rapid construction, testing, and part replacement. Additionally, a simple mounting system was necessary to assist with setup. These considerations led to adopting the following design specifications: 1) using a slider controller, a breath controller, and a touch sensor; 2) ensuring ergonomic practicality, ease of setup, and using off-the-shelf materials.

The design process was a collaborative effort between an assistant and me, guided by drawings I provided to communicate my envisioned design. We tested physical prototypes at each stage, engaging in discussions to identify issues and explore potential improvements. As the project evolved, so did our understanding of our respective roles. The assistant contributed expertise in electronics, particularly in guitars and synthesisers, while I applied my knowledge of sensor technologies within Digital Musical Instruments (DMI).

Although I led the design process through drawings and functional planning, the assistant provided valuable input during prototype construction, offering feedback that informed design refinements. The physical prototype was developed over several months through collaborative construction and testing sessions, interspersed with periods where I independently redesigned elements based on autobiographical reflection. I assessed challenges and opportunities during these intervals, incorporating additional features. With each sensor or component added, I played the instrument to evaluate its responsiveness, identify limitations, and uncover new possibilities for improvement at each stage.

5. TECHNICAL SPECIFICATIONS

5.1 Materials and Construction

The possibility of using readily available off-the-shelf materials and technologies made constructing the design and integrating parts and technologies simple and time-efficient. The initial prototype was built using cardboard tubes to ensure simple testing of the coupling between physical interfaces and sensor technologies. Once satisfied with this coupling, we moved to use a more robust material - PVC plastic pipe - as this was still easy to construct with and add objects and sensors to, but provided more stability and rigidity. One of the most challenging aspects was to develop bracket attachments to connect the instrument to the wheelchair. The initial baseplate that connects the project box to the camera bracket was constructed of plywood. However, this setup proved too flimsy, so an aluminium ad-hoc version was developed and engineered to increase the stability.

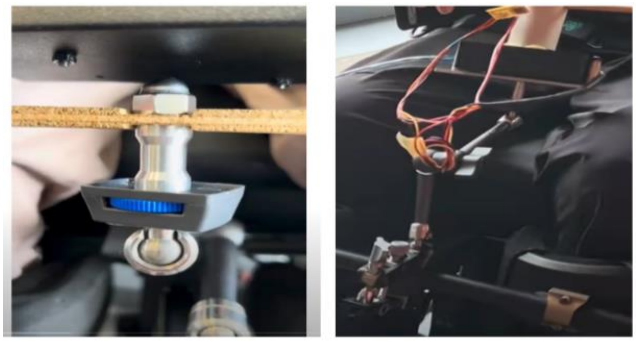

Figure 1. Camera Bracket Single Point Fixture From Wheelchair to Baseplate

5.2 Interface and Sensor Integration

The instrument incorporates multiple gestural interfaces and sensors integrated with MaxMSP via Arduino. Key components and their functions include:

Pitch Slider and Ultrasonic Sensor: A 1 cm wooden dowel inserted into the instrument's slide mechanism controls the inner tube. An ultrasonic sensor positioned at the tube's base measures the slide position (distance) and sends this data to MaxMSP for pitch control. Initial experiments used a breadboard with an Arduino Uno, later replaced by a printed circuit board (PCB) mounted above the Arduino and housed in a project box attached to the instrument.

Pressure Sensor and Melodica Mouthpiece: A pressure sensor, connected to a plastic tube repurposed from a catheter bag, registers breath output. This setup, paired with a melodica mouthpiece, connects the instrument to the specific needs of my disability. The sensor controls note initiation, dynamics, and sustain, allowing expressive breath-based interaction.

Register Key and Membrane Potentiometer: Initially, a 38 mm square force sensor was installed as a register key for pitch modulation, akin to a saxophone's register key. Due to activation challenges, it was replaced by a 200 mm soft pot membrane potentiometer. This larger surface area enables precise control and allows multiple points to trigger different transpositions or register shifts.

Master Volume Fader: An analogue slide potentiometer, mounted on the front of the project box, serves as a master volume control. Positioned within my range of movement, it allows for adjustments to overall output during practice or performance.

Structural Elements and Accessibility Features: The system includes a custom aluminium base plate and a camera bracket to attach the instrument securely to my wheelchair. Components such as the project box, Arduino Uno, ultrasonic sensor, pressure sensor, membrane potentiometer, and analogue fader are integrated seamlessly for stability and ease of use.

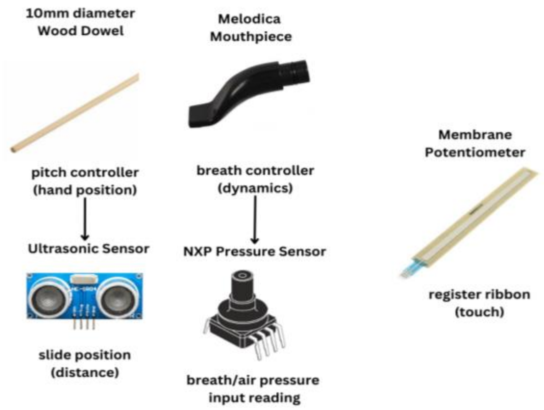

Figure 2. Coupling of Sensors and Functions

Sensor data is transmitted through a serial USB connection to a computer, enabling real-time interaction. The pairing of interfaces (e.g., pitch slider with ultrasonic sensor, pressure sensor with breath input) ensures the instrument is responsive and tailored to my physical abilities, enhancing playability and expression. The coupling and mapping from the interface through the sensor, and ultimately to a computer, is shown in Figure 2. The MaxMSP patch provides a choice of multiple scale sets for the slide to activate. There is also the option of FM or Additive Synthesis, the ability to adjust how the register ribbon can function, and a visual reference for notes being played. Figure 3 shows a design concept detailing the placement of the interfaces and sensors onto the instrument.

6. REFLECTION AND EVALUATION

After developing the Slide-A-Phone, I spent two to three one-hour sessions per week over three weeks performing with the instrument and reflecting on its qualities against the findings of the analysis of my saxophone recordings. I would play scales, note patterns or pitch sets, simple tunes, and improvise freely unaccompanied and accompanied by my assistant or 'Band in a Box'. Although early in developing skill sets for this instrument, observations of its playability are positive and encouraging. Even from the early stages of prototype development, the Slide-A-Phone enabled me to play and repeat phrases in a way that had not been possible since my accident. If I got a note wrong, I could find the right position to replay it correctly, highlighting how the instrument's auditory feedback instructed the slide's position. With practice, there were noticeable improvements in playing simple scales or melodies.

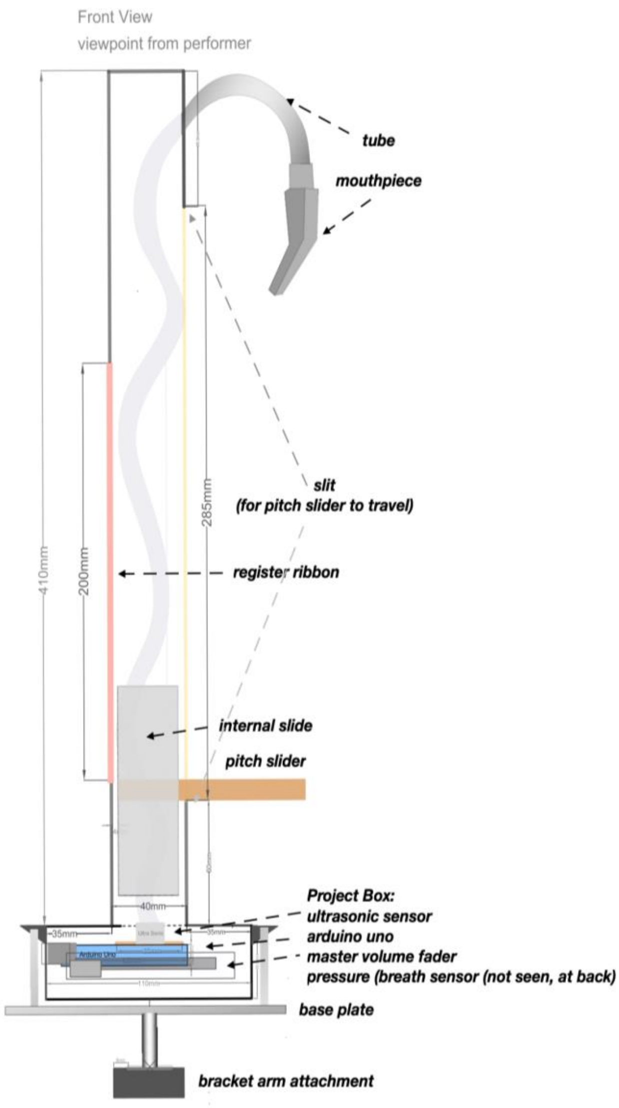

Figure 3. Diagram of the Placement of Interfaces on the Slide-A-Phone

I formally evaluated the Slide-A-Phone by testing the extent to which I could play in time with a regular tempo of 88 bpm with the software "Band in a Box," which provides sequenced backing tracks for practising melodies and improvisation. I also practised with my assistant, accompanying me on a Casio keyboard, using the rhythm machine. Revisiting "Band in a Box," a tool I used during my early years at Jazz School, offered a meaningful reference for progress as a disabled musician using the Slide-A-Phone. While I have managed to play a few melodies such as ‘Night and Day’ Strangers in the Night’, and ‘Fly Me to the Moon’ at a slow tempo (88 bpm), the instrument's structural instability currently affects my ability to transition smoothly between notes, requiring further refinement. Figure 4 was taken during a session where I played Cole Porter’s ‘Night and Day’ over the band in a box backing[6]. This shows the three interfaces: the left-hand controls pitch, the right-hand controls register, whilst my breath through the mouthpiece controls articulation, dynamics, and tonal texture.

A notable experience was performing with the New Zealand music art group "From Scratch" during their 50th-anniversary celebration. This event marked the debut of the Slide-A-Phone in a live setting, with the piece featuring rhythms from metal bars tuned to the F Lydian scale—one of the scale sets in the MaxMSP patch. I improvised freely with their rhythms and tones, developing material as the performance progressed. It is worth mentioning that I consider myself a beginner playing the prototype, tasking myself with working on playing through simple scales and patterns. These tasks are achievable but require some effort and concentration at this stage. However, I feel the speed, accuracy, and flow of playing scales and exercises successfully will become easier with practice as my agency with the instrument improves.

7. DISCUSSION

This study provides new insights into ADMI design through the specific methodologies employed and the integration of diverse design practices. First, a particular contribution is made through sharing how pre-accident experiences and recordings can inform new designs. Emphasising the role of critical and systematic analysis of pre-disability performance recordings as a design probe, assisted with understanding the expressive and technical qualities central to the musician-instrument relationship [8, 19, 23]. Incorporating these elements through an autoethnographic approach informs an autobiographic design perspective, offering a novel methodology centring the musician’s lived experience in ADMI development. By emulating and reinterpreting pre-disability musical techniques, this approach facilitates continuity when addressing challenges in post-disability musical expression while introducing a framework for integrating reflective analysis into the design process.

Second, we noticed that involving an assistant in the co-design process added a layer of practical insight and collaboration. This participatory approach, integrated with autobiographic design, resulted in a concept driven by personal initiative while incorporating external contextual input throughout the development process. [1, 26]. Combining the autobiographic and collaborative design methods demonstrates the importance of lived experience and iterative feedback in instrument design in creating not just a functional instrument, but one with emotional resonance [12, 13, 16]. Drawing from standard and self-developed extended Occupational Therapy practices provided unique perspectives on accessibility. This project demonstrates the value of applying this approach - developed from earlier work - to the design framework. [3, 19].

This study demonstrates how integrating analysis, reflective practice, and diverse design methods can guide the development of ADMIs with haptic or tactile interfaces, fostering intuitive control, expressive performance, and creative agency.

By sharing this methodology and its outcomes, this research offers a transferable model for designers and researchers aiming to create instruments that prioritise the needs and experiences of musicians with diverse abilities.

Figure 4 Playing the Slide-A-Phone

8. CONCLUSION

This article outlined the development of the Slide-A-Phone, a bespoke AMI. The instrument originated from reflections on past audio recordings and evolved through an autoethnographic, collaborative, and ability-based design approach into a functional prototype. The design process was informed by an analysis of movements and functions, using data gathered from standard and extended occupational therapy methods to create a user-centric instrument. The prototype successfully emulated pre-disability playability by integrating haptic and tactile connectivity, allowing the user to perform simple musical tasks and exercises that had been inaccessible since becoming disabled.

The Slide-A-Phone is expanding my ability to collaborate and create music beyond experimental soundscapes, fostering diverse and nuanced musical expression while opening new opportunities for musical exploration. Future iterations will focus on improving playability and addressing current challenges, such as stability issues related to the single mounting point. However, even in this early stage, the first authors' experience has been positive, particularly regarding the instrument’s connectivity and playability. The following stages will also include other disabled and non-disabled musicians playing the Slide-A-Phone to share their insights for future development.

[6] Night and Day with Band in a Box @ 88 bpm

9. ETHICAL STANDARDS

The authors do not identify any other conflicts of interest, or any other ethical issues identified in relation to this work. The assistant mentioned in this article was funded through Disability Services University of Auckland, Te Whare o ngā Pūkōrero Pūoro Waipapa Taumata Rau Aotearoa (New Zealand). Generative AI tools were only used to check grammar and for linguistic refinement.

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