# Music jamming as a participatory design method. A case study with disabled musicians

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## ABSTRACT

We propose a method that uses music jamming as a tool for the design of musical instruments. Both designers and musicians collaborate in the music making process for the subsequent development of individual "music performer's profiles" which account for four dimensions: (i) movements and embodiment, (ii) musical preferences, (iii) difficulties, and (iv) capabilities. These profiles converge into proposed prototypes that transform into final designs after experts and performers' examination and feedback. We ground this method in the context of physically disabled musicians, and we show that the method provides a decolonial view to disability, as its purpose moves from the classical view of technology as an aid for allowing disabled communities to access well-established instruments, towards a new paradigm where technologies are used for the augmentation of expressive capabilities, the strengthening of social engagement, and the empowerment of music makers.

## Author Keywords

Disabled musicians, jam session, design method, participatory design

## CCS Concepts

•Human-centered computing → Empirical studies in accessibility; *Accessibility technologies;* •Applied computing → *Sound and music computing;*

## 1. INTRODUCTION

Music is a fundamentally collective cultural process and a rich part of the human experience [1] that requires complex cognitive and social abilities such as coordination, empathy, agility and strength [16, 5]. On the other hand, the use of readily available technologies such as flexion, pressure or movement sensors to create new customized musical instruments could help enhance performers' capabilities and expressiveness [8, 2, 4]. The use of these technologies is of special interest in the case of designing for or with disabled

people [1] [15, 20, 25, 13], if we take into account that disablement can be defined as "the gap between one's bodily abilities and the requirements demanded of that body by a given environment" [28, 17]. In the context of music performance, this gap relates not only to the auditory sense, but also to vision (communication with the instrument and with other musicians) and the sense of touch (for instance, haptic feedback from instrument [23]). Moreover, there are deep social and cultural factors that shape these gaps in music making [12]. For example, traditional musical pedagogies are ruled by ableist epistemologies where talent and musicianship are narrowed down to specific physical skills such as precision and technical alacrity [31].

Here we introduce a novel design method for the ideation of new or modified music instruments that focus precisely on this contextual and multi-level (physical, social, emotional) character of disability. We claim it is key to regard music playing as a socially embedded process where the actual physical impairment is just one more from a myriad factors. In this way, rather than adapting an already existing instrument to give access to a particular disabled community, the design process centers in the plurality of bodies so the resulting instrument emerges from the complex and situated relationship of each performer with their body, their instrument and their musical context. This aims to contribute to the recent change of focus from a disablement-centered perspective to a situated [12] and decolonial [32, 9] design process where the instrument is seen as an augmentation of musicians' bodies and self- expressiveness - in defiance of pre-established colonial standards [14] - and a way of fostering social engagement and empowerment [6].

The approach we propose here is a three-stage method comprised by (1) a semi- structured music jam session (i.e., collective music improvisation) and a subsequent analysis of what participants observed, listened and felt, (2) individual performers profiles obtained from the data collected through the jam sessions, and (3) prototyping, feedback from performers and experts, and building of the final instruments. We describe two cases of how we used these profiles to design and build instruments for two performers with marked

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Figure 1: An example of the jamming setup. Standing students lead the rhythm and record. Seated students and performers play along.

different interests, background and characters.

## 2. FIRST STAGE: MUSIC JAMMING

For our sessions, we involved five kids from the Teletón [2] rehabilitation centre (hereafter referred to as the performers) and a group of eighteen undergraduate students from the Austral University of Chile, coming from three different careers: music, computer engineering and occupational therapy. Four researchers and lecturers of Austral University of Chile acted as coordinators of the experience (here called the coordinators).

The group gathered in a room with several music instruments available to choose freely. They were instructed to work in teams of five to six people. Each team was composed by one or two performers plus four students. One of the students was in charge of presenting the activity - here referred to as the facilitator. A second student had the task of video and audio recording the activity for subsequent analysis. The two other students would take part in the jam as musicians. The facilitator of the activity acted as the "tempo leader" by playing some simple percussion instruments such as clave or a wooden block (see Figure 1).

The activity started with the creation of a musical score based on a template (see Figure 2). The simplicity of the template was intended to foreground the expressive and social over the technical aspects of music playing, therefore minimizing potential inhibitions that could impede both students and performers to partake in the activity. The score consisted of two horizontal lines for each instrument, each of these corresponding to the left and right hand. The group had to fill out the score with their own composition, such as a simple rhythm, as a starting point (see Figure 2). They were invited to freely create their own musical notation language. Once the scores were completed, the "tempo leader" initiated the jam session by clapping, tapping or playing a simple beat and thus acting as the group metronome. After going through the initial score a few times, players could start improvising for around ten minutes. After the round finished, the facilitator interviewed the group to find out their preferred parts of the jam, their difficulties, and the overall interaction experience. Then, teams were instructed to create a new score of a slightly higher complexity than the previous one and to start jamming again. This process was repeated for three rounds.

A combination of different data collection methods was used: (1) direct observation of the music performance in order to evaluate the performers' dynamics, including their interaction and reactions, (2) documentation through video and audio, and (3) open interviews to assess the performers'
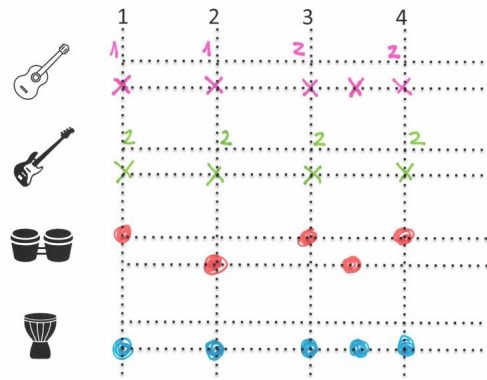


Figure 2: Example of the score used. Each group developed its own notation.

experience. We foresaw some advantages of using a jam session as a design method :

1. Direct assessment of physical capabilities through observing and listening. Each musical instrument becomes also a tool for embodied assessment. Some of the features that can be quickly assessed are, for instance: blowing capacity (wind and brass instruments), hands and arms strength, fine motor control (guitar, bass), gross control (drums), among others.

2. It allows designers to grasp performers' musical preferences and previous knowledge.

3. Body gestures may give some insights on personality: different kinds of personalities may interact very differently both with the instruments and with the co-performers.

4. Music acts as a social lubricant, allowing participants easily engage with each other. This promotes openness to talk about their own difficulties, abilities, tastes and concerns regarding not only music performance, but the whole physical and social experience that represents a jamming. It also opens to conversations about the background of each other: why do they want to play an instrument, what does an instrument means for them, for instance.

5. The method tries to hide the observer, avoiding the anxiety generated from playing for others. It places the performer in a safe and non-judgemental environment for self-expression.

## 3. SECOND STAGE: GENERATION OF PERFORMERS PROFILES

Subsequently, students gathered in the same groups to assess and discuss the obtained data [3]. The instruction was to complete a profile for each performer, comprising four dimensions: (1) movements and embodiment, (2) musical preferences, (3) difficulties, and (4) capabilities. Each dimension is articulated as a set of questions – illustrated in Table 1.

We designed this particular format of performer profile envisioning the following potential advantages:

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[2]Teletón is a non-profit organisation that supports disabled people aged from 0 to 24 years old

[3]We acknowledge that the excluding of performers in this stage could have been a flaw of the method. We discuss this issue in Section 6

| 1. Movements and embodiment | 2. Musical preferences |
|---|---|
| What are the typical gestures of the performer? | It is the performer a follower or a leader? |
| Which is their dominant hand (i.e. left or right)? | Do they propose melodies, or do they rather prefer to play in the background? |
| Do they use marked/fast or subtle/slow gestures? | Do they tend to faster the rhythm? |
| Do they use the whole body to play or just specific parts of it? | Do they prefer some specific instrument or an instrument family? |
| | Do they have any musical background? |
| **3. Difficulties** | **4. Capabilities** |
| Does the performer have or express a difficulty with particular gestures/movements? | Is there a particular rhythm the performer followed easily when compared to other players? |
| Is the performer having problems in engaging or communicating with the rest? | Is there any physical particularity that makes easier the performance for them? |
| Are there any psychological aspects hampering their music performance? | Is there any psychological aspect that could enhance their performance? |

Table 1: Questions guiding the generation of a performer profile. The profile was divided into four dimensions

1. Multidimensionality: It considers both the somatic and the musical aspects of music making experience, taking into account the preferences and capabilities of the player.

2. Distancing from ableist epistemologies: The questions do not reference to a particular impairment or physical disability. Rather, they aim to individualize the performer in the musical/physical/social realm that constitute the music jamming, where the physical impairment could appear only if it is important in any of these dimensions.

## 4. THIRD STAGE: PROTOTYPING AND BUILDING

From the obtained profiles, we asked each team to elaborate a proposal of one or two instruments for each performer. The instruments had to considerate not only the explicit requirements of each performer (captured by the facilitator in stage one) and their musical and performative characters (captured by the profiles in stage two), but they also had to be realistic in schedule (i.e. they had around two months for building the instruments) and limited budget. In order to make sure all these requirements were met, each team presented their prototypes to the coordinator team, which was composed by four experts on design and disability, building and making, digital musical instruments, and electronics, respectively.

After coordinators' feedback, each team presented their final prototypes to each performer and captured their feedback to decide which one was their preferred (if more than one prototype was available) and any modification they would suggest.

Each team had unrestricted access to the workshops and materials from the *Leüfulab* [4] maker space during the two months of building. Also, coordinators acted like tutors

whenever any specific complex tool (3D printing, laser cutting) was needed.

A final event was organized for the delivery of the instruments, and everyone that participated throughout the project was invited to attend (performers, students, coordinators, technical staff, authorities from the participating institutions). In the event, each team handed out the instrument to the corresponding performer and then they took one hour to explore together the possibilities of the instruments (trying different timbres, styles, techniques). Finally, everyone gathered for a final jam session where we brought several additional instruments so everyone could join the jam. A video of the final event and interviews of participants experiences is available in the project website [5].

## 5. RESULTS AND DISCUSSION

We will here describe two cases of designed instruments from the application of this method, in order to show how it reveals the different musical, physical and socio-emotional characteristics of each performer, and the subsequent solutions that emerged for each case. We end up the discussion by reviewing the flaws and possible improvements to our method, situating it as a first step towards a truly co-design method that includes disabled musicians in every part of the process.

The first case was a performer with one (left) functional arm, while lacking the right forearm. The performer profile is shown in Figure 3 left panel. During the music jamming, this performer managed well with simple percussions such as the tambourine, giving the designer team hints of previous musical knowledge. Nonetheless, the performer tended to hide and/or follow patterns rather than proposing or improvising. In the final interview, the performer showed a marked reluctance to play instruments with a low learning curve (i.e. easy to play), explaining that those were the ones that they (singular pronoun) were often supposed to play, given their impairment. Besides, the performer showed

[4] https://leufulab.cl/

[5] https://luthiersxxi.home.blog/

interest in classical instruments rather than electronic interfaces. These factors posed an interesting restriction to the design team. Very often, when adapting music instruments to specific needs, the designers tend to rely on digital interfaces or sensors that simplify the interaction for the performer. Examples of this are electronic interfaces with pre-programmed scores such as Cymis [2], music gloves that track functional hand movements [10], robot-assisted guitar playing [30], among several others [19]. However, this ease in the performance often hinders the possibility of developing more complex and intimate relationships with the instrument [33] as well as - in the case of purely digital instruments - the loss of instrument physical feedback to the player, such as the so called haptic cues (vibration felt through player's body) [23] . Then, in this case, the challenge was to develop technology that allows the performer to experience a classical music instrument and minimizing the technological intervention in order to keep the original instrument's features. The cello was proposed as a suitable candidate because of its complex learning curve, together with being an accompaniment instrument rather than a soloist instrument, thus following the performer's preferences. Two prototypes were presented to the performer: a digital cello that could be played with one arm - the sound would automatically start whenever they pressed the fingerboard with the left hand - and a 3D-printed prosthetic forearm, which would allow the performer to play a non-intervened classical cello. Following their original inclination for acoustic classical instruments, the performer showed a special interest for the second prototype. In Figure 4, upper panel, we show the developed prosthetic forearm. The performer showed very excited about the result. However, a shortcoming - to be discussed later - was that when trying it, the performer commented that the prosthetic forearm socket needed more fine tuning for them to be able to exert more pressure against the cello.
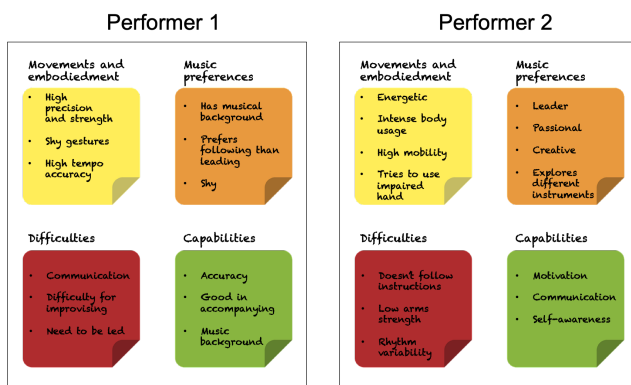


Figure 3: A comparison of two contrasting cases of performer profiles: at the left side "the virtuoso follower", and at the right side "the energetic improviser".

The second case shows a performer that, in contrast to the first one, was very playful and open to exploring and improvising with the instrument, even without having any music formation. The performer tried to use their impaired arm to lean on or to help the other hand (see performer profile in Figure 3 right panel). In the musical scope, the performer showed interest in several instruments, always taking a leading role in the group. The performer rapidly tried to explore new ways of using each instrument, to sound them as loud/quiet as possible and, in general, to obtain new timbers and sounds rather than following structured melodies or repeated patterns. The design team proposed a one-handed flute to the performer. Although excited about the idea, the performer was interested in the flute as a way of exploring a wide range of "crazy sounds and effects". Taking this into consideration, the team developed a "magic flute" (Figure 4, lower panel). The flute was designed for the performer to easily change timbres on the computer, affording the exploration of a rich variety of sounds. In addition, the design team devised a starter manual to propose playful first experiences that the performer could easily follow, also helping them to perform more structured and repetitive patterns, fostering concentration and focus on specific tasks.



Figure 4: Upper panel: The resulting instrument for the "virtuoso follower" performer was a prosthetic forearm that would allow them to play the conventional cello. At the right side is shown the original design proposed by the design team. Lower panel: For the "energetic improviser" the design team developed a one-handed MIDI flute that was connected to a synthesizer software allowing the performer to explore a wide spectra of timbres.

The comparison of the two performers makes evident the turn from an ableist epistemology towards a multilevel and contextual view of music performance that this method provides. Although the actual physical impairment was similar for both performers, their resulting profiles were markedly different, and so were the resulting instruments. The centrality of disablement vanishes to give space to a complex and contextual analysis of each performer. The disability only stands out in how performers are being aware of their specific impairment and how this influences their interaction with the instrument and their social behaviour. The built instrument, in this way, is no longer an assistive technological solution but rather a situated object through which performers interact with their musical environment.

The latter aligns with a decolonial view of disability. As Thumlert and Nolan [31] assert, technology - and particularly HCI - usually relates to disability either through a medical approach - i.e. technology for rehabilitation - or through an accessibility approach - i.e. technology for giving disabled communities the same opportunities than non-disabled ones. Despite the fact that successful music instruments have been created following both approaches (see, for instance, [24, 26, 18]), critical studies on disability have relentlessly pointed out that both approaches usually fall in the same Western hegemonic logic: they still try to fit the disabled into a (socially constructed) normality [7, 3, 11], thus hampering the possibility of disabled communities in

being an active voice in the definition of their own requirements. In the music-making context, hegemonic cultural factors shape a desired hyper-abled body and narrow down musicianship to specific technical skills, thus disqualifying bodies with a "self- evident" disability [31]. New music instruments, then, instead of aiming to fit diverse bodies into this normal canon, should help to deconstruct this "ableist model" and social construct of disablement. We suggest our method defies fixed social constructs of music making as it focuses on the multi-sensorial and multi-layered process of music making and what it is emerging from a situated social process that is music jamming. The open-ended character of a jam session constitutes an important factor in allowing different voices to emerge and letting each performer take a role in a situated process. This is complemented by the performers' profiles that narrow down the resulting characters into grounded features that can be translated into a specific design.

# 6. FINAL REMARKS: A CRITICAL RE-FLECTION

As usual, no method is completely successful, and focusing on flaws and failures can also provide insights for future developments and improvements.

A first point to note is that performers should have had an even more active voice in the design process. Echoing the social model of disability and the adage "nothing about us without us" [29, 28], it is fundamental that disabled musicians are involved in each stage of the design process. In our case, although performers would partake in the music-making and design feedback process, the proposed designs were commissioned strictly to students, leading to a power unevenness in the creation process.

Secondly, from the beginning of the experience, the designs were thought only for disabled musicians. If we claim that our method focuses on fostering expressiveness in a plurality of bodies, then it surely should not be limited to disabled musicians. Moreover, by focusing on disabled musicians, we might still maintain some of the discourses that differentiate disabled performers from a "normal" performer. It would be interesting to see what happens if we extend this method to heterogeneous populations/users, where disabled users are just one more among myriad users. However, the challenge here would be to ensure that disabled communities' voices don't get lost among people perceived as more credible or holding more power and agency.

As noted by Mankoff et al [22], it is quite common that non-disabled communities fall into an assistive role when working with disabled communities. We saw this attitude, particularly in some students who would overtly express their "willingness to help" the disabled performers. We think it is fundamental, especially when working with students, that there is an initial framing of the process, where the goals of each part are clarified and the expectations are unified. For example, Sitbon observes [27] that while it is often clear what disabled musicians will gain from the interaction (e.g. an adapted instrument), it is not that clear for the disabled musicians what students are obtaining from the project, which could enlarge this assistive view. Instead, emphasising that students are not only learning but even being assessed from the resulting designs would switch this view towards a mutual understanding within the context of the project.

Finally, when custom and technologically mediated music instruments, the long-term use and technical support are crucial [21]. We realized that after students finished their term, no technical support would be available for musicians that would run into problems with their instruments (e.g. some sensors stopped working, and some software needed updating). Also, throughout practice performers might find need of modifications to the instrument like the case of the prosthetic arm socket described in section 5. An alternative to this - that would at the same time enhance empowerment - would be to provide performers not only with an instrument and musical guidance but also with technical skills such as small tutorials on how to handle software/hardware and even maker and DIY guidance. Obviously, this would entail some new challenges, such as the adaptation of DIY tools for the specific needs of each musician.

# 7. CONCLUSIONS

This work describes the case study that uses music jamming and the development of performer profiles for the design of musical instruments for disabled musicians. The openness and non-goal-oriented character of a jam session provides a playful environment that allows the expression of performers without worrying about ableist-centred concepts such as virtuosity and alacrity. This also allowed the appearance of "musical personalities" which were subsequently characterized through the performers profiles. These profiles took into consideration four dimensions: (i) movements and embodiment, (ii) musical preferences, (iii) abilities, and (iv) difficulties. We then described the development of two performers profiles that showed marked differences, the first one being a "virtuoso follower" and the second one an "energetic improviser". For each case, different instruments were proposed and built to match their own personalities and expectations. Finally, as shown in the developed performer profiles, and according to what several design experts have asserted, this method entails a turn from an impairment-centered perspective into a multi-dimensional analysis taking into account specific capabilities and features of each individual, focusing in the relationships between the performer and their bodies, the instrument, and other performers. In this way, the method contributes to the goal of blurring some of the societal barriers imposed for disabled population, by treating impairment as any other challenge in music performance (e.g. lack in coordination, inaccuracy in movements, lack of rhythm, among others). In this way, we shift the focus from "assistive" or "adaptive" design to new interfaces affording situated music expression. Finally, we suggest improvements to our methods in order to enhance disable musicians empowerment.

As future work, we believe the proposed method could be extended to a much broader scope than design. Its participatory character touches upon several individual and social aspects of music performance, including motivation, social collaboration, physical therapy, creativity and education, among others.

## Ethics Statement

## Acknowledgements

## 8. REFERENCES

[1] D. A. Abrams, S. Ryali, T. Chen, P. Chordia, A. Khouzam, D. J. Levitin, and V. Menon. Inter-subject synchronization of brain responses during natural music listening. *European Journal of Neuroscience*, 37(9):1458–1469, 2013.

[2] K. Akazawa, T. Ichinose, K. Matsumoto, M. Ichie, T. Masuko, and R. Okuno. Novel electronic musical instrument with pre-programmed score for the disabled to enjoy playing music. *Advanced Biomedical Engineering*, 6:1–7, 2017.

[3] G. Armagno. The role of hci in the construction of disability. In *The 26th BCS Conference on Human Computer Interaction 26*, pages 1–4, 2012.

[4] A. D. Aziz, C. Warren, H. Bursk, and S. Follmer. The flote: an instrument for people with limited mobility. In *Proceedings of the 10th international ACM SIGACCESS conference on Computers and Accessibility*, pages 295–296, 2008.

[5] L. Badino, A. D'Ausilio, D. Glowinski, A. Camurri, and L. Fadiga. Sensorimotor communication in professional quartets. *Neuropsychologia*, 55:98–104, 2014.

[6] M. Bandukda, A. Singh, C. Holloway, N. Berthouze, E. Brulé, A. Tajadura-Jiménez, O. Metatla, A. Javornik, and A. Thieme. Rethinking the senses: A workshop on multisensory embodied experiences and disability interactions. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–5, 2021.

[7] C. Barnes. Understanding disability and the importance of design for all. *Journal of accessibility and design for all*, 1(1):55–80, 2011.

[8] E. Brulé. Playing music with the head. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 339–340, 2016.

[9] L. P. Cadavid. Knotting the memory//encoding the khipu: Reuse of an ancient andean device as a nime. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2020.

[10] N. Friedman, V. Chan, D. Zondervan, M. Bachman, and D. J. Reinkensmeyer. Musicglove: Motivating and quantifying hand movement rehabilitation by using functional grips to play music. In *2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, pages 2359–2363. IEEE, 2011.

[11] A. Hamraie. Universal design and the problem of "post-disability" ideology. *Design and Culture*, 8(3):285–309, 2016.

[12] J. Harrison, A. Chamberlain, and A. P. McPherson. Accessible instruments in the wild: Engaging with a community of learning-disabled musicians. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–6, 2019.

[13] N. Hendriks, K. Slegers, and P. Duysburgh. Codesign with people living with cognitive or sensory impairments: a case for method stories and uniqueness. *CoDesign*, 11(1):70–82, 2015.

[14] K. Höök, S. Eriksson, M. Louise Juul Søndergaard, M. Ciolfi Felice, N. Campo Woytuk, O. Kilic Afsar, V. Tsaknaki, and A. Ståhl. Soma design and politics of the body. In *Proceedings of the Halfway to the Future Symposium 2019*, pages 1–8, 2019.

[15] A. Ilsar and G. Kenning. Inclusive improvisation through sound and movement mapping: from dmi to admi. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, pages 1–8, 2020.

[16] V. Iyer. Improvisation, action understanding, and music cognition with and without bodies. *The Oxford handbook of critical improvisation studies*, 1:74–90, 2016.

[17] A. Kabel. Disability, the senses and apparel: Design considerations. *The Senses and Society*, 11(2):206–210, 2016.

[18] P. Kirk, M. Grierson, R. Bodak, N. Ward, F. Brander, K. Kelly, N. Newman, and L. Stewart. Motivating stroke rehabilitation through music: A feasibility study using digital musical instruments in the home. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 1781–1785, 2016.

[19] J. V. Larsen, D. Overholt, and T. B. Moeslund. The prospects of musical instruments for people with physical disabilities. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2016.

[20] J. Lobo, S. Matsuda, I. Futamata, R. Sakuta, and K. Suzuki. Chimelight: Augmenting instruments in interactive music therapy for children with neurodevelopmental disorders. In *Proceedings of the 21st International ACM SIGACCESS Conference on Computers and Accessibility*, pages 124–135, 2019.

[21] A. Lucas, F. Schroeder, and M. Ortiz. Enabling communities of practice surrounding the design and use of custom accessible music technology. *Computer Music Journal*, 44(2-3):9–23, 2020.

[22] J. Mankoff, G. R. Hayes, and D. Kasnitz. Disability studies as a source of critical inquiry for the field of assistive technology. In *Proceedings of the 12th international ACM SIGACCESS Conference on Computers and Accessibility*, pages 3–10, 2010.

[23] S. Papetti and C. Saitis. *Musical haptics*. Springer Nature, 2018.

[24] S. T. Parke-Wolfe, H. Scurto, and R. Fiebrink. Sound control: Supporting custom musical interface design for children with disabilities. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2019.

[25] G. Pullin and J. Higginbotham. *Design Meets Disability*. Taylor & Francis, 2010.

[26] G. Ragone. Designing embodied musical interaction for children with autism. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, pages 1–4, 2020.

[27] L. Sitbon. Engaging it students in co-design with people with intellectual disability. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–6, 2018.

[28] A. Skuse and S. Knotts. Creating an online ensemble for home based disabled musicians: why disabled people must be at the heart of developing technology. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2020.

[29] K. Spiel, K. Gerling, C. L. Bennett, E. Brulé, R. M. Williams, J. Rode, and J. Mankoff. Nothing about us without us: Investigating the role of critical disability studies in hci. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–8, 2020.

[30] H. Taheri, J. B. Rowe, D. Gardner, V. Chan, D. J. Reinkensmeyer, and E. T. Wolbrecht. Robot-assisted guitar hero for finger rehabilitation after stroke. In *2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, pages 3911–3917. IEEE, 2012.

[31] K. Thumlert and J. Nolan. Angry noise: Recomposing music pedagogies in indisciplinary modes. *Handbook of Theory and Research in Cultural Studies and Education*, pages 1–23, 2019.

[32] J. Tragtenberg, G. Albuquerque, and F. Calegario. Gambiarra and techno-vernacular creativity in nime research. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2021.

[33] D. Wessel and M. Wright. Problems and prospects for intimate musical control of computers. *Computer Music Journal*, 26(3):11–22, 2002.