Towards Neurodiverse Sensemaking: Pluralizing Agency in Wearable Music and Participatory Workshopping

Seth D. Thorn, PhD
seth.thorn@asu.edu
Arts, Media and Engineering
Arizona State University
Tempe, Arizona, USA

Anani Vasquez, PhD
avasquez@neurodiversitycenter.org
Neurodiversity Education Research Center
Phoenix, Arizona, USA

Corey Reutlinger, PhD
corey.reutlinger@asu.edu
MLF Teachers College
Arizona State University
Tempe, Arizona, USA

Margarita Pivovarova, PhD
margarita.pivovarova@asu.edu
MLF Teachers College
Arizona State University
Tempe, Arizona, USA

Mirka Koro, PhD
mirka.koro@asu.edu
MLF Teachers College
Arizona State University
Tempe, Arizona, USA

Figure 1: Youth participate in a stretching session while wearing inertial measurement units (IMUs) wirelesssly coupled to laptops that generate music in the classroom.

Abstract

We, a team of teachers and researchers, share examples of collectively playable instruments that challenge normative assumptions about intention and agency in digital musical instruments. These instruments enliven neurodiverse sensemaking in participatory design and STEAM learning. Through a multiyear research-practice partnership (RPP), we collaborated with teaching fellows to co-design a curriculum for neurodiverse middle school students that activates computational thinking (CT). This collaboration led to a web-based, quasi-modular interface connected to wearable music sensors. We situate our work within the growing literature on participatory design of collaborative accessible digital musical instruments (CADMIs). We describe how our co-design methods address the complex demands of ecosystemic thinking, sensitive to the varied entanglements that complicate traditional human-computer interaction (HCI) design and evaluation methods. Our pedagogical and methodological approach diverges from deficit-focused strategies that aim to develop neurotypical communication skills in neurodivergent individuals. Instead, we promote cross-neurotype collaboration without presuming a single mode of "correct" communication. Furthermore, we surface the potential of CADMIs by linking this notion to a pluralization of agency that extends beyond one-to-one body-sensor relationships. We develop accessible instruments within neurodiversity and autism contexts, avoiding reification of mindbody relations and recognizing them as dynamic, field-like, and embedded in facilitative relations for these communities.

Keywords

Neurodiversity, Accessible Digital Musical Instrument, Computational Thinking, Wearable Music, Entanglement

NIME '25, June 24—27, 2025, Canberra, Australia

1 Introduction to Neurodiverse Sensemaking

Pluralizing agency is a key affordance of technology-infused arts practice. This surfaces especially in collective dance improvisation (CDI) and has a rich history (e.g., field-based, relational media constructed by John Cage and Merce Cunningham in the 1960s

[37]). By contrast, the more recent evolutions of this technology in ubiquitous, ambient, and wearable computing have moved towards a normative ontology rooted in a classical, atomistic understanding of the individual.

Research on accessible digital musical instruments (ADMIs), in turn, has grown within NIME, with a recent shift from assistive "adaptation" of preexisting instruments–often viewed unfavorably by the disabled community for perpetuating ableism [42]–towards more participatory and flexible design processes for creating accessible instruments [15]. This shift is evident in the trend toward speculative design and the use of tools that facilitate generative design of novel instruments [2, 16]. Recent literature also includes work with autistic or neurodivergent individuals [24, 60, 61].

In our RPP, called NEWMT ("Neurodiverse Educational Wearable Music Tech"), we put forward a plural and diversifying "neurodiverse sensemaking," a turn of phrase we use to frame our combination of speculative co-design [1], embodied and participatory sensemaking [10], development of CADMIs, and our adoption of a fourth-wave "entanglement HCI" perspective [14]. Drawing on HCI techniques utilizing embodied sensemaking to drive playful first-person encounters using tangible artifacts [21], we programmed wearable inertial measurement units (IMUs) that could be embedded in props or worn on the body, using a paradigm of relational parameter mapping sonification that pluralizes agency (see Figure 1). For this project, we did not develop CADMIs as tools to correct or assist neurodiverse sensemaking in view of privileged neurotypical and linguistic models such as turn-taking, but rather constructed CADMIs as ways to create friction with neurotypical models of intention and agency. These kinds of digital musical instruments do not map one-to-one with bodies in space. Instead, they disrupt isolated, linear, and cognitivist models of volition, thought, and movement, potentiating sensitization to neurodiverse sensemaking—a term that does not indicate “neurodivergent sensemaking,” as is often misunderstood in the literature, but rather the full plurality and breadth of sensemaking: ways of communicating and being in the world, including both neurotypical and neurodivergent modes, without privileging one over the other.

Too often the term "collaborative" is freighted with colonialism, assuming that collaboration should proceed in a neurotypical way. This approach misunderstands the social model of disability, which can only be systems-based, inter-relational, and always becoming [39]. In this project, collaboration is always open to neurodiverse ensembles and ways of being together, which is also essential to our conception of neurodiverse sensemaking. While third-wave HCI has turned away, to a certain extent, from neurotypical linguistic models that beset interaction design in order to discover more primary modes of embodied and tacit being-together [23], this approach still tends to engrain the notion of a determinate "user" with certain features or characteristics that can be designed for outside of the determinacy and unique entanglements of a particular situation.

Haraway reminds us that all "critters" and matter, human and more-than-human, "become-with each other, compose and decompose each other, in every scale and register of time and stuff in sympoietic tangling...earthly worlding" [18]. All processes, including processes in our research, are relational and thus they interact with other processes, matter, and actants [5]. Drawing on Barad’s agential realism, we emphasize that "relations precede relata" [4]. These recondite expressions orient us toward possibilities difficult to express, drawing us into a speculative element that we seek to make felt (i.e. "felt meaning" [17]) and embodied in our workshops through what we have previously called "collectively playable" instruments [51, 52], but adapt here to a more critical adoption of the recently proposed "CADMI" category [25]. These instruments use statistical aggregates of motion features and relational contingencies to sensitize participants to the entanglements and heterogeneities of neurodiverse sensemaking and experience.

To summarize, participatory design has been, for us, computationally augmented, embodied speculation on ways of relating that do not privilege a particular neurotype in situations of cross-neurotype collaboration. Hence we view the pluralization of agency as the key affordance of wearable music technology. This also enables us to offer a more radical notion of a CADMI, based on relationality, that moves past some previous literature (see e.g. [24]).

This paper builds upon recent CADMI literature (e.g., [24]) but departs from therapeutic or assistive framings by emphasizing cross-neurotype co-design, entangled agency, and the activation of CT concepts through collectively playable instruments, grounded in neurodiversity theory and process-oriented HCI. We outline: (1) key research and theory on neurodiversity, (C)ADMIs, and collaboration; (2) exemplars from recent NIME or adjacent literature that surface tensions and possibilities; (3) our framing of neurodiverse sensemaking and computational thinking; and (4) reflection on our NEWMT project’s co-design methodology and outcomes.

2 Background and Related Work

2.1 Neurodiversity: Foundational Paradigms and Social-Relational Perspectives

Nick Walker initially noted that “neurodiversity is the diversity of human minds, the infinite variation in neurocognitive functioning within our species," which formulates the basis for the neurodiversity paradigm as a holistic perspective that values neurodiversity and renounces the idea of a “normal” mind or a “right” kind of neurocognitive functioning, and acknowledges neurodiversity’s socio-political dynamics [57]. Neurodiversity integrates biological and political dimensions, challenging assumptions of a “normal” mind and emphasizing identity rather than pathology [7, 57]. Rather than framing impairments as individual deficits, the social-relational model positions disability as emerging from the interaction between individuals and systemic conditions [39].

Further, extending from biological and evolutionary neurodiversity approaches, Chapman [7] outlined a social ecological model of mental functioning that focuses on propensity traits and niche contributions that can be addressed at both the individual and group levels. For example, he states that there are several autistic cognition capabilities (e.g., hypersystematizing, hyper attention to detail, intense focus) that can lead to specific niches (e.g., computer culture). In this example, the focus is on characteristics that are viewed as strengths. Likewise, a person’s deficit characteristics, at the individual level, can contribute to necessary group functions. Less attunement to neurotypical social conventions, for instance, can lead to increases in original thought and a decrease in sensitivity and reaction to social pressures. Most important, neurodiverse groups (i.e., groups composed of individuals with differing neurocognitive functioning styles) have a wider range of mental resources for problem-solving and dealing with uncertain situations as well as less propensity towards confirmation bias [7]. Operating from the neurodiversity paradigm, thus, promotes a shift from individual pathology to relational dys/function, with the goal of decreasing disability stigma and increasing collaborative creativity. In turn, such a shift can destigmatize neurodiverse ways of sensemaking. This perspective informs NEWMT's work on neurodiverse tech workplaces and employer training [41].

2.2 Process, Entanglement, and Agency

The neurodiversity paradigm also emphasizes how fluid, ongoing processes—rather than fixed traits—emerge through intra-actions among bodies, minds, and environments. This process-oriented, relational view resonates with broader shifts in HCI and musical interface design, with increasing attention to the entangled, emergent nature of agency and interaction.

Despite the increasing adoption of processual approaches to understanding NIMEs [45]—paralleling a push, based on Barad's agential realism [4], to adopt entanglement as HCI's "fourth wave" [14]—the NIME literature still lacks a more critical understanding of processuality as it relates to neurodiversity. Though the neurodiversity movement has been active for over two decades, its influence in NIME remains limited, with Wright being the notable exception to explicitly draw on this framework [60, 61] and others mentioning or acknowledging the term without addressing its criticality (see e.g., [24, 26, 30, 32]).

Nonetheless, there are signs of a growing post-normative understanding of agency within or adjacent to NIME. For example, McPherson's critique of "smart" instruments, approached from the lens of entanglement, questions the value of instruments that attempt to model or represent a performer's intentional state [33]. This is problematic not only because such representations often fail (e.g., the machine misinterprets the "notes"), but because of the myriad assumptions papered over in the concept of "intentionality" itself, and how intentionality is recognized and practiced.

In ADMI design, the drive to stabilize agents and relationships becomes problematic when confronted with the complexities of neurodiversity, which demand a serious consideration of "crip spacetime" [42] and fluid non-binary processes. This necessitates recognizing that agency itself is not fixed, but dynamic, porous, and embedded in a network of changing relations (see, e.g., [4]). More so, cripping spacetime, here, implies a pluriversality and intersectionality of ADMI designs to represent neurodiversity and autism fully, where agency is multiplicative, overlapping, and competing within and against oppressive normative structures. A neurodiversity perspective helps deconstruct the traditional "volition-intentionality-agency triad" [31] that still underpins much of NIME theory, despite the growing call for ecosystemic approaches in both academic discussions and conference organization.

Even as NIME embraces more sophisticated enactive and embodied approaches, the conception of ecology as a "community of agents" [45] remains rooted in "interaction," a perspective that agential realism, which has gained momentum in HCI over the last five years [33], critiques as restrictive. By contrast, neurodiversity advocates for an understanding of relations as intra-active [4], incomplete, and multi-sensory, forming a stronger and more fluid sense of ecology. This shift might help resolve long-standing discomforts with the concept of "interaction" in computer music (e.g., [11]).

Neurodiversity also deepens the implications of enactive, sensorimotor approaches to thought, where action and perception are undifferentiated. This perspective sidesteps the need for an intentional subject as a computational intermediary who builds an internal model of the world [13]. For neurodivergent individuals, sensorimotor loops, such as "stimming" or adaptive responses, are performances of sensemaking that challenge conventional divisions between sensory input and intentional action [8, 27, 36].

In ADMI research, neurodiversity similarly exposes the moralized biases in evaluation protocols that separate sensory and cognitive modalities [9]. Such perspectives overlook the holistic nature of sensorimotor experience [38], succumbing to technologically pre-theorized models that divide the senses. Thus, in this study, neurodiversity, far from being an exception, serves as a baseline that challenges these colonial distinctions, with important implications for accessibility.

2.3 Collective Dance Improvisation (CDI) as Entangled Sensemaking Model

Collective Dance Improvisation (CDI) offers a lens to expand "thought" beyond linear, rational, or purely symbolic systems. Maxine Sheets-Johnstone underscores the kinetic dimension of thought, "the interfusion of sense and movement," which surfaces what language often obscures [48]. By intensifying group exploration of intention and movement, CDI reveals a fluid blend of leading and following—dancers simultaneously move and are moved—exposing the undecidability of distinct roles. The kinetics and fluidity of CDI are pertinent to neurodiverse sensemaking, since many neurodivergent people engage in nonverbal, nonlinguistic, or less conventional modes of communication. CDI makes these multiple modes of expression central to group interaction rather than peripheral or pathological.

CDI also aids in studying complex system dynamics in lived experience. Himberg et al. leverage CDI to track emergent group-level phase transitions, revealing qualitative shifts in collective affect [20]. Drawing on Barad's agential realism, we label these bifurcating shifts "agential cuts," which illustrates why, for instance, five bodies need not imply five discrete subjects. This resonates with third-wave HCI's blurred boundary between designer and user [58], and with Barad's reminder that "quantum phenomena are not limited to some alleged 'micro' domain" [4].

Himberg's approach further leverages participatory sensemaking [10]. The latter framework has informed "embodied sensemaking" [21] and somaesthetic design [23] in HCI, methodologies which foreground nonverbal communication and coordination through action, rather than relying solely on verbal exchange—an idea echoing Sheets-Johnstone's "kinetic bodily logos" [48].

Historically, Cage and Cunningham embodied a similar ethos in 'analog' music technology, using photocells and capacitive antennas to transform the stage into a responsive instrument [37]. By treating ambient light as a relational field, they sidestepped engineering-centric discourse in favor of body-based play. These experimental arts practices align with neurodiverse sensemaking by recognizing that the multiplicity of mindbodies co-construct experience together. Today, networked wearable computing broadens such possibilities, enabling collective, room-scale digital instruments that transcend individual control. Attuned to the body's natural affordances (e.g., rotational movements), these wearables mirror a neurodiverse perspective.

These toolkits use sensorimotor dynamics and relational mappings to support emergent behaviors. Replacing control with "wonder" [46], CDI and related approaches pluralize agency in ways that align with neurodiverse sensemaking.

Our previous research has actively developed these principles through a series of participatory projects involving wearable music technologies. We have explored how process-oriented co-design enables entangled, improvisational forms of sensemaking in both in-person and telematic settings [50, 51]. These systems challenged linear mappings and single-user intentionality by leveraging collectively playable interfaces that distribute agency across participants [52]. The present work builds directly on this trajectory, extending it through a deeper engagement with neurodiversity, computational thinking, and multi-sensory pedagogy.

3 Exemplars from Recent Literature

To ground our argument in practice, we examine three recent case studies (published within the past year) that illuminate critical issues at the intersection of neurodiversity and wearable/music technologies. Drawn from NIME and journals adjacent to NIME, these studies generate opportunities and challenges, clarifying how design choices can either reinforce or disrupt normative assumptions about agency, communication, and collaboration (see Table 1 for a summary outline.)

3.1 Ivanyi et al.: Therapeutic Practices and Neurotypical Goals

For instance, Ivanyi et al. leveraged insights from therapeutic practices and collaborative technology theories to support social, collaborative, and communication abilities [24]. The most intensive recent engagement in the NIME literature with autistic youth, it is interesting to note, though, that this research included only autistic youth co-designers while focusing on nonautistic or neurotypical social communication and collaboration skills. Although the inclusion of autistic co-designers is aligned with the neurodiversity paradigm, the focus on changing communication behaviors to fit neurotypical conventions is not. To develop social communication and collaboration for the "real world," cross-neurotype (or neurodiverse) groups of co-designers could be used. This would encourage the development of social problem solving and communication skills without designating one way as better or normal.

Additionally, several neurotypical assumptions were made in the work of Ivanyi et al., including the assumption that autistic children lack awareness of others, that social abilities should be assessed based on neurotypical conventions, that all youth participants could speak, read and write at the same level or in the same way (for questionnaires and social interactions), and that neurotypical goals should be chosen for autistic children (without their input as to what would be helpful to them). Interventions here supposed that autistic children had to do the changing rather than the environment, including the technological capabilities, or some of both. Furthermore, the research design of Ivanyi et al. was evaluated through a case study and an existing rating scale. Both of these design choices utilize representativeness of the sample and standardization of responses which connect this study to neurotypical knowledges. Similarly, Ivanyi et al. stated that the "importance of clear guidelines for effective ideation was underscored," which foregrounds the right, correct, and clear way of engaging in thinking and doing, thus often reflecting neurotypical processes.

Alternatively, it is possible to co-design with autistic and non-autistic (i.e. neurodiverse) students in ways that develop all of their communication and collaboration skills with the objective of teaching abstract concepts, such as CT, that are necessary and beneficial to all students. Additionally, one can assume that bodies are always in relation; therefore, people, technology, and other more-than-human entanglements are in various states of attunement with each other. The experiences within our own NEWMT methodology (detailed subsequently) aligned more closely with interactive educational technology to support learning, rather than technology to implement an intervention, following the assumption that no subgroup of students needed to change to better mimic another and that all students could learn together. Our co-designers also continuously pushed against the assumption that literacy (i.e. reading, writing, speaking, listening to verbal input) is the dominant mode for knowledge making by designing learning experiences that relied heavily on movement and music and by attending to multi- and cross-sensory intra-actions (see Figure 2).

Figure 2: Youth engage with NEWMT technology and lesson plans during a summer camp for our RPP.

3.2 Nonnis and Bryan-Kinns: E-Textile TUIs for Autistic Children

The learning experiences facilitated by NEWMT, both with teachers and students, were based in play, or open-ended, playful interactions with the people, technology, and props available in the learning environment. Although we know that play is crucial for child development and is supported by the United Nations Convention on the Rights of the Child (UNCRC) as a fundamental right for all children [55], we also know that some children, including autistic children, can experience anxiety and discomfort during "play" experiences because of unwritten social expectations and unpredictable physical environments. Nonnis and Bryan-Kinns note that many autistic children experience heightened anxiety in social settings due to environmental factors (e.g., lighting, sound, spatial layout) and the social dynamics often present with neurotypical peers. [34]. Additionally, they emphasize that promoting socially engaged play requires adjusting both the physical environment and the attitudes of non-autistic adults and researchers to better support neurodivergent children's needs, including their self-regulatory behaviors like stimming. These researchers focused on increasing inclusivity for social play by expanding technological design and rejecting medicalized or pathological approaches to design. They specifically moved beyond the typical screen-based devices, virtual reality, and robots to explore tangible user interfaces (TUIs) to "foster socially engaged and spontaneous play of and between [minimally

Table 1: Comparison of Case Studies and Alignment with NEWMT

Case Study	Design Assumptions	Alignment with Neurodiversity	Our Divergence / Extension
Ivanyi et al.	Therapeutic framing; improving social skills via neurotypical norms	Partial – includes autistic youth co-designers, but centers neurotypical communication goals	Foregrounds cross-neurotype co-design and avoids correction-based framing
Nonnis & Bryan-Kinns	Sensory-friendly TUIs; play-based interaction; non-verbal communication	High – designs accommodate autistic preferences, encourage self-regulation and embodied play	Adds live music/sensor mapping to broaden TUIs into CT learning tools
Harrison & McPherson	Instrument as adaptable tool; balancing musical and therapeutic goals	High – supports diverse uses and user-defined goals, including sensory regulation	Focuses on CT and co-design integration in school learning environments

verbal to nonverbal/nonspeaking, or non-conventionally verbal] autistic children."

Likewise, our NEWMT methodology included professional development on neurodiversity and the co-designers continually engaged in reflection to expand our understanding of and ability to create neurodiversity-affirming spaces, technology, and activities. Similar to NEWMT, Nonnis and Bryan-Kinns's co-design project moved beyond words, but in this case by mediating activities with shareable e-textile TUIs developed to reflect children's preferences and interests. In this way, researchers used an ecological approach to intentionally encourage children's authentic selves through meaningful (to the children) interactions, aligning well with the neurodiversity paradigm. Nonnis and Bryan-Kinns also rejected assumptions that autistic children have deficits in social skills and intrinsic motivation for play by recognizing these as signs of neurotypicality, "the right way to play and socialize," and by accepting autistic differences in play and communication styles (e.g. less symbolic play, less social play, more self-regulatory behavior, more balance between private and social time and space, use of whole body to communicate). This resonates with the "double empathy" problem in which neurotypical people lack empathy with autistic culture and vice versa.

Nonnis and Bryan-Kinns advocate for TUIs for socially enabled interactions because of benefits like:

- Providing sensory feedback for self-regulation.
- Usability by multiple people (shareability).
- Multiple entry/access points (less competition for access).
- Inviting engagement with group activity.
- Perceptual (social awareness), manipulative (active interaction), and fluid (easy flow of interaction).

The use of musical TUIs can be powerful for emotional and sensorimotor regulation and mood management. Nonnis and Bryan-Kinns found that children responded best to their TUIs (Olly and Mazi) based on "the robustness of the design, its versatility defined by its ambiguous form and openness, the sensory stimulation provided, its configuration, size, and possibly its mobility." Movement seemed to especially encourage collaborative play while providing proprioceptive and vestibular input (e.g., deep pressure, rocking). Music further invited children to explore TUIs and supported shared attention. "Robustness of design" was a factor in our NEWMT development, especially in the creation of a wearable CADMI that could also be attached to other props (see Figure 3).

Figure 3: An elementary school STEM teacher engages with NEWMT technology during an open community workshop. Multiple M5-Stick devices, based on the ESP32, connect to a web-based quasi-modular interface via BLE-MIDI. The teacher manipulates two of the three connected sensors, exploring the relational dynamic and effect on the musical feedback.

3.3 Harrison and McPherson: Strummi and Varied Access Needs

The work of another team of researchers, Harrison and McPherson, is pertinent to NEWMT [19]. This team demonstrates nuances of accessibility with Strummi, their guitar based ADMI, with learning-disabled musicians. They discuss the shift from a focus on technical solutions for accessibility to designing instruments that can "change depending on the artistic intentions and personal values of the musician" and from "instrument-as-device" to "musician-as-user." Additionally, Strummi was designed from both an engineering mindset and a music innovation mindset and was used for therapy and/or performance depending on the musician/user's values. NEWMT co-designers included musicians and a music teacher as well as individuals with little music background. Therefore, it was important to build in the capabilities needed for teaching and learning music theory as well as designing instruments that could be explored to develop CT concepts, the educational goal of the project. Furthermore, a somewhat "therapeutic" use also evolved at one school where certain students preferred to engage with NEWMT technology during their sensory breaks from the classroom. NEWMT technology was used for stress relief, stimming, calming, and refocusing before students returned to classroom instruction (see Figure 4).

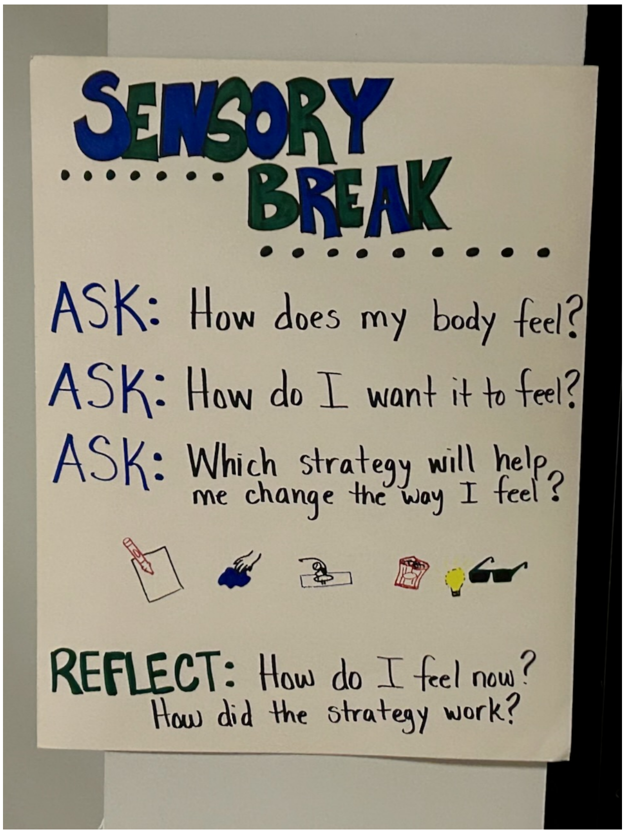


Figure 4: During a summer camp hosted by our RPP, a poster in our sensory break room suggests scaffolding for neurodiverse reflection.

In their study, Harrison and McPherson noted that although Strummi participants shared a common neurodivergent identity, "they all had a range of access needs; some of which the Strummi was more suited to addressing than others." Data from Strummi sessions illustrated "that access and accessibility are not always possible to measure or quantify for a general population" and that barriers to access could be physical or attitudinal "towards what constitutes musical skill and musicality." Likewise, some NEWMT teachers were concerned about engaging and teaching with wearable musical instruments that incorporated various levels of music theory when they did not consider themselves musicians or musical while other teachers who were musicians, but did not consider themselves technologically savvy, were also challenged to engage.

Additionally, there were points during the NEWMT project where the question, "Is that music, though?" came up (e.g., with a soundboard instrument called "Sports Orchestra") and values around what constitutes music came into question. In the Strummi project, the feedback from participants centered around differing individual music-making values, some of which included music-making for physical or social development (therapeutic) as well as for music enjoyment and performance. Although the Strummi was not designed as an assistive device or for therapeutic activities, some participants valued the instrument for these possible attributes. Both the NEWMT and the Strummi studies demonstrated neurodiversity approaches that did not assume deficits or engineer devices for neurotypical intervention, but were open to neurodivergent use and feedback about the needs, whether musical or disability-related, of the participants.

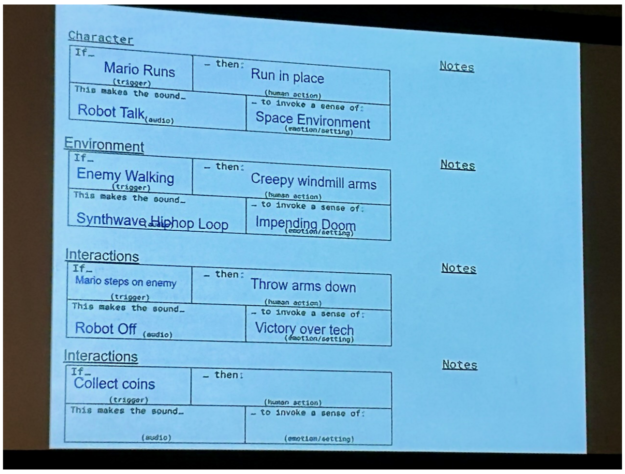


Figure 5: A sheet of sample strategies for linking together collective play, CT, and NEWMT sensors, designed to accompany video game play, is projected onto a large screen during the NEWMT summer camp. Youth filled out the sheet, which scaffolds the concept of if—then logic.

4 Neurodiverse Sensemaking and Computational Thinking

While Ivanyi et al. focused on social goals framed by neurotypical norms, our work foregrounds entangled and plural forms of sensemaking through shared play and CT exploration. We extend the openness of TUIs (as seen in Nonnis & Bryan-Kinns) by integrating real-time musical feedback to support relational improvisation.

Designing for neurodiversity in the context of education requires heightened perception with regard to the entanglement of affective, sensory, and cognitive fields, and the way the parsing of these categories translates or reflects entrenched neurotypical attitudes in the classroom. A chair, for instance, scaffolds certain neurotypical assumptions about the compartmentalization of affect and attention [56]. Learning from CDI, we know that dancers do not represent themselves via a mental projection of their bodies in Euclidean space, but are embodied in their ongoing and unparsed dynamic movements and thinking-feeling with others through the "kinetic bodily logos" [48]. For neurodivergent individuals, moreover, projecting the body into space may be too abstract without grounding in corporeal symmetries.

While novel music technology has been adopted in music education, there are recent attempts to connect NIMEs and/or musical coding with CT and computer science (see e.g., [35, 53, 54]. For our RPP, we envisioned activating CT by having participants manipulate parametric control interfaces of instruments they wear, which would coincide with the adaptation to diverse corporeal and sensory needs through the choice of salient movement, gesture, and sound. Concepts of scaling, inversion, and boolean logics, for instance, are tools for crafting and coding unique responses through tinkering (see Figure 5).

STEM-rich tinkering practices for emergent CT can be found in the NIME literature (e.g., [12, 53]. Indeed, the notion of CT is sufficiently broad to encompass practically any activity involving open-ended tinkering and problem solving in a context of learning. Thus, Tsoukalas and Bukvic provide an adequate, and helpfully terse, definition of CT in the context of their paper as "problem-solving using computers." But this is only one of many possible definitions, because CT is in essence a provocation that requires researchers to adopt provisional definitions in their research, typically involving multiple facets including "decomposition, abstraction, algorithm design, debugging, iteration, and generalization," although lack of a model is emphasized in review literature [49]. In her seminal article on CT, Jeanette Wing avoids an explicit formulation of CT [59]. For our purposes, we have found it productive to align CT with neurodiversity and computer science with neurotypicality. Moreover, we avoided categorical alignment of music with computation by also leaning on rhetorical (i.e., expressive) practice, the experience of the body as a voice or sound generator, which may be important in the context of autism. Thus, CT is a step closer to lived experience–once rather than twice removed from the plurality and plenitude of the lifeworld.

5 Neurodiverse Sensemaking within NEWMT

5.1 Participatory Design, Sensemaking, and Sensorimotor Coupling

Neurodiverse approaches to research include participatory approaches, such as co-design, which is based on Design-Based Research (DBR), a flexible, future-oriented methodology that can be used to build theory and knowledge about learning and design while being directly useful to a specific context [3, 40]. Participatory design, through systematic iterations in complex and fluid environments, can advance theory while impacting instructional practice [3]. Participants are invited, as capable, empowered co-designers, rather than subjects of an intervention. Table 2 summarizes how each activity aligns with core CT principles.

Our sensemaking framework draws from the field of neuroarts, which challenges "the traditional [Western] visual dominance…critically examined in the context of sensory design and phenomenology" [22]. Neuroaesthetics explores neural mechanisms in aesthetic experiences, and together with neuroarts expands prevalent understandings of emotions and responses to stimuli. Further, "art engagement goes beyond aesthetic appreciation, actively exercising the brain and contributing to neuroplasticity" [22]. By emphasizing multiple brain systems during artistic engagement (motor, sensory, reward pathways, perception), we open the door to multi- and cross-sensory design. This aligns with our interest in embodied sensemaking, music, and tangible artifacts.

5.2 Methodology and Context for NEWMT

To recruit teaching fellows for the project, we used previously developed material as well as a new set of custom instruments to generate excitement about "wearable music." We recruited a sample of four middle school teachers, two of whom taught STEM classes, one music, and another physical education. All teachers taught at least some students with autism labels, and most taught students from low-income communities.

These instruments were intended as an embodied sensemaking toolkit to elicit playful, first-person perspectives for our teaching fellows. During our initial workshop, however, we noted that several teaching fellows were unsure of how to engage. We brought

Figure 6: A choreographer guides and enlivens participation from group of teaching fellows during the first year of our RPP, introducing an element of somatic connoisseurship.

in a choreographer to support somatic connoisseurship [47], focusing on sensorimotor coupling that recognized the entangled nature of bodies, technology, and environment (see Figure 6).

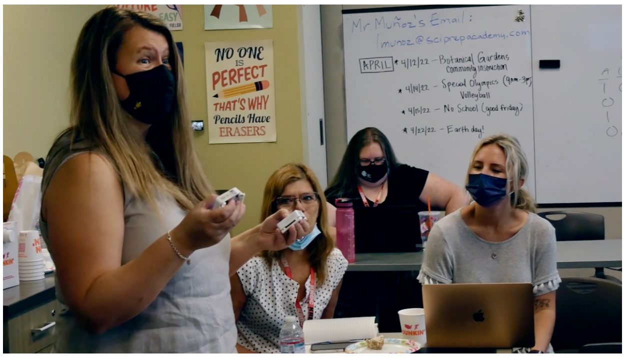


Figure 7: During a workshop early in the RPP, a team member comments on an instrument that provides haptic feedback according to the (a)synchrony of the two IMUs.

5.3 Instrument Prototypes

Our initial instrument prototypes embedded CT concepts through varied interaction paradigms. These included wearable interfaces modeled after metaphors like a rainstick (see Figure 8, a clacker, and a wind-up "Catapult," each leveraging motion data to drive granular synthesis or algorithmic playback. "Wearable Jazz" engaged small groups in distributed sonic roles. Together, these instruments surfaced concepts like indexing, boolean logic, and continuous vs. discrete control, aligning sound-making with computational exploration.

In our original prototypes, we explored ways of distributing characteristics of these instruments across multiple bodies/IMUs, for instance by embedding choices of AND/OR logic to gamify hold and release gestures for the Catapult for a group of individuals, and to provide haptic feedback when gestures of winding the Catapult fall within a selected range of variance of angular momentum, linking the players together in contingent ways (see Figure 7). Likewise, the clacker instrument employed simple windowing techniques to analyze the density of events generated over time, which could be directly or inversely correlated to various sound parameters in addition to individual voicings. For the

Table 2: Sample Lesson Plans Connecting CT Concepts with NEWMT Activities

Lesson Name	CT Concept	Description	Activity Format
Beat Breakdown	Decomposition	Break drumbeat into component parts	Jam with Wearable Jazz
Algorithm of Sound	Algorithm	If—then mappings between movement and sound FX	Game interaction + live triggering
Sound Charades	Abstraction	Represent motion patterns using sound	Pantomime and guessing
Sports Orchestra	Pattern Recognition	Map sports gestures to sounds	Group improvisation

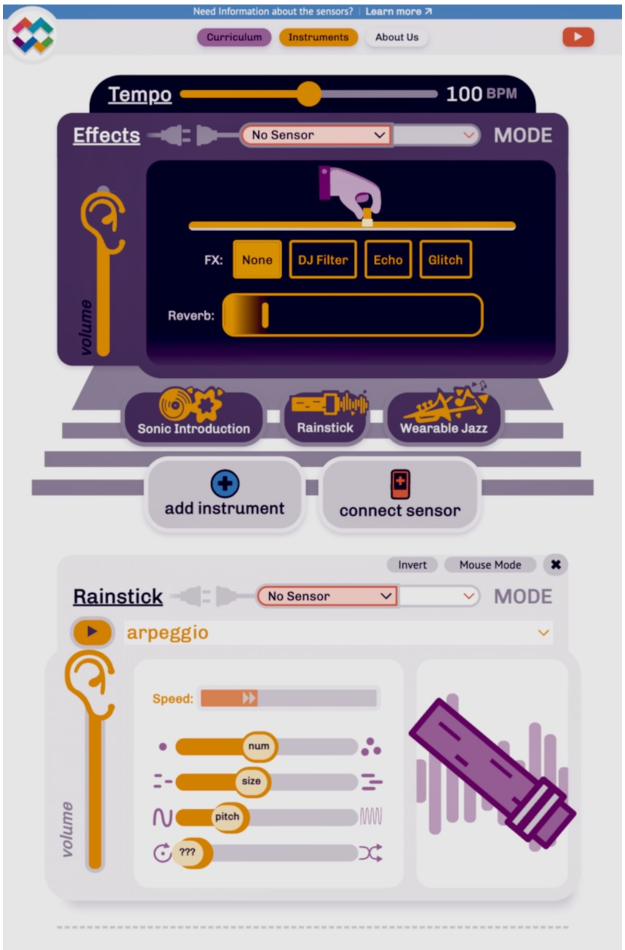


Figure 8: A semi-modular, browser-based interface for constructing NEWMT instruments. The back-end was developed using Cycling74's new RNBO environment. In this image, an instance of the Rainstick instrument has been created, inheriting characteristics from our original prototype. More instruments can be added and linked to multiple sensors, creating a vertical chain of modular connectivity in the browser window.

rainstick, selection of a statistical operator (min, max, or mean) generated an aggregate angle across multiple IMUs. Wearable Jazz links together kick drum hits, bass tones, and chord changes, which affect the musical scales available to other players.

From the beginning, it was important that the sound design be rich and suggestive of electronic and popular music and with which students were familiar. Likewise, it is important for design teams to include diverse team members who have motivations other than narrow research outcomes. Much like the "aesthetics of failure" that evolved from the de-scripting of academic technologies into a broader cultural phenomenon [28], our design efforts were mediated by input from teachers and designers who bridged academic and practical concerns. The development of a robust front-end for the web interface, considerations of longevity and scalability, and the increasing red-tape around technology in schools all shaped our iterative process [12].

5.4 Pedagogical Integration: Sample Lesson Plans for CT

Below are four representative lessons co-developed through our RPP. Each surfaces a CT concept—decomposition, algorithm, abstraction, or pattern recognition—and illustrates how collectively playable instruments that enrich neurodiverse sensemaking evolved from our early prototypes through co-creative design with diverse teachers and youth (see Figure 10).

5.4.1 Beat Breakdown (Decomposition). Students dissect a multi-layered drumbeat (kick, snare, hi-hat) into smaller parts. They first "jam" with the Wearable Jazz instrument to observe how distinct sensor inputs trigger specific drum sounds, then reassemble a familiar rhythm in groups. This connects with breaking tasks down in real-world activities.

5.4.2 Algorithm of Sound (Algorithm). Learners design if—then "audio algorithms" by mapping sensor motions to game-inspired sound effects. In pairs, one student mutes a video game while the other triggers corresponding audio. Swapping roles and exchanging feedback refines algorithmic thinking and supports inclusive collaboration (see Figure 9). Extensions include Foley-style soundscapes and a "Robot Obstacle Course" for visually impaired learners.

5.4.3 Sound Charades (Abstraction). Students focus on abstraction by creating and guessing "sound signatures" through pantomimed motions. After exploring sensor axes (pitch, roll, shake) to produce distinct timbres, they represent these motions on a graph or reduce them to minimal visual cues.

5.4.4 Sports Orchestra (Pattern Recognition). Students map baseball actions (pitch, swing, run, catch) to sensor-triggered sounds. Through experimentation, they identify recurring patterns and broaden the notion of "performance" to include collective, multisensory artmaking.

5.5 Teacher and Student Engagement in NEWMT

For the NEWMT project, the co-designers integrated educational standards such as CT while also drawing on UDL guidelines [6]. UDL principles emphasize:

- Engagement (the "why" of learning): interest, effort, self-regulation
- Representation (the "what" of learning): perception, language, symbols, comprehension
- Action and Expression (the "how" of learning): physical action, expression/communication, executive function

Because many students faced barriers to traditional literacy or verbal participation, we emphasized music, embodied interaction, and multi-sensory "intra-actions" to open alternative routes to collaboration. Learning experiences facilitated with NEWMT were based in play, or open-ended, playful interactions with the people, technology, and props in the learning environment [44]. Yet we also recognized that for some children, including autistic children, "play" can be fraught with anxieties about social norms and environmental unpredictability. Thus, the teaching fellows and co-designers continually sought to create safe, flexible, and inclusive spaces where stimming, movement breaks, and creative self-expression were not only allowed but encouraged.

Several teachers also reported that certain students gravitated to NEWMT instruments during sensory breaks. Engaging with wearable musical instruments for stress relief, stimming, and calming before returning to classroom instruction exemplified the ways in which these technologies could serve therapeutic or regulatory functions—despite not being explicitly designed as assistive devices. This echoes prior examples like Strummi [19], where instruments were adaptable to a range of uses, from therapy to performance.

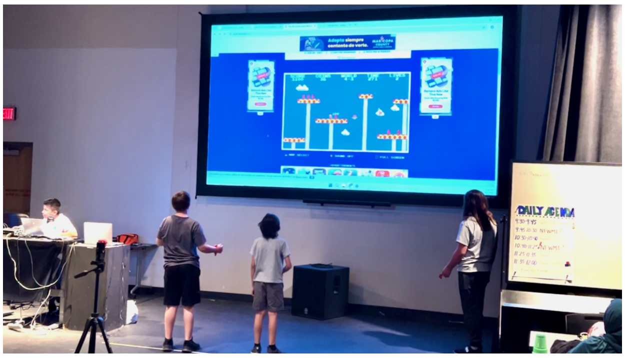
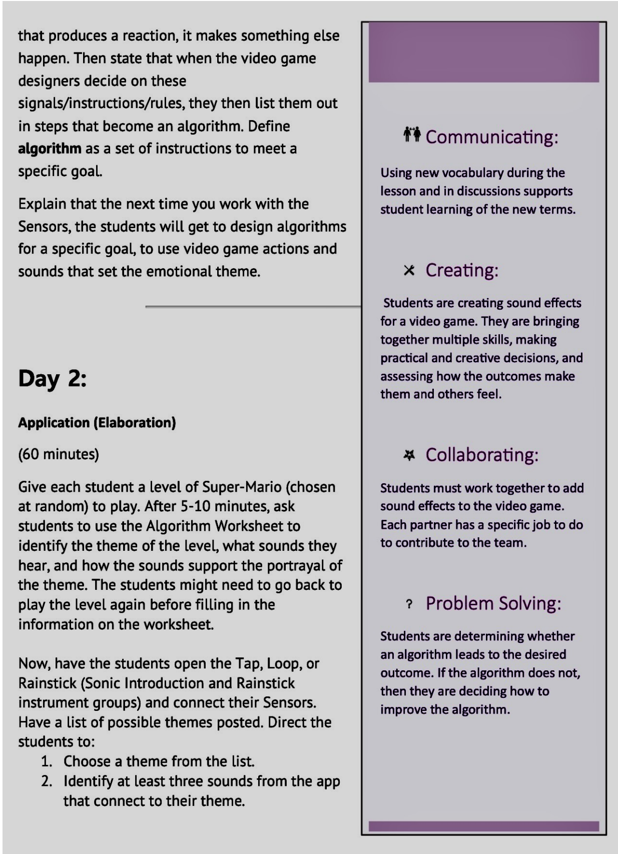


Figure 9: Youth align musical gestures and sounds they have selected with playing Super Mario during the NEWMT summer camp.

5.6 Topological, Relational, and Computational Thinking

Throughout NEWMT, we observed that the focus on bodily movement, parametric tinkering, and relational sound-making sparked awareness of CT concepts (e.g., loops, conditionals, scaling). Students and teachers found it rewarding when personal gestures led to immediate auditory feedback, which in turn motivated experimentation. Moreover, we asked whether a topological, fluid sense of motion could be reconciled with the discrete, schematic



that produces a reaction, it makes something else happen. Then state that when the video game designers decide on these signals/instructions/rules, they then list them out in steps that become an algorithm. Define **algorithm** as a set of instructions to meet a specific goal.

Explain that the next time you work with the Sensors, the students will get to design algorithms for a specific goal, to use video game actions and sounds that set the emotional theme.

Day 2:

Application (Elaboration)

(60 minutes)

Give each student a level of Super-Mario (chosen at random) to play. After 5-10 minutes, ask students to use the Algorithm Worksheet to identify the theme of the level, what sounds they hear, and how the sounds support the portrayal of the theme. The students might need to go back to play the level again before filling in the information on the worksheet.

Now, have the students open the Tap, Loop, or Rainstick (Sonic Introduction and Rainstick instrument groups) and connect their Sensors. Have a list of possible themes posted. Direct the students to:

1. Choose a theme from the list.
2. Identify at least three sounds from the app that connect to their theme.

Communicating:

Using new vocabulary during the lesson and in discussions supports student learning of the new terms.

Creating:

Students are creating sound effects for a video game. They are bringing together multiple skills, making practical and creative decisions, and assessing how the outcomes make them and others feel.

Collaborating:

Students must work together to add sound effects to the video game. Each partner has a specific job to do to contribute to the team.

Problem Solving:

Students are determining whether an algorithm leads to the desired outcome. If the algorithm does not, then they are deciding how to improve the algorithm.

Figure 10: An excerpt from a downloadable PDF lesson plan from the NEWMT website. This lesson, called "Algorithm of Sound" explains how students design algorithms for video game sound effects. They play Super Mario, analyze sound themes, and use sensors with NEWMT apps to connect movements with sounds. The above page also highlights social-emotional skills like communication, creativity, collaboration, and problem-solving as students refine their algorithms.

representation in the computer interface. By bridging the smooth continuity of movement and the abruptness of symbolic logic, participants encountered moments of tension that facilitated learning [43].

Collectively playable CADMIs discouraged dominance by any single user, nudging participants to attend to each other's gestures. Teachers observed increased engagement among students with autism, suggesting that neurodiverse interaction can support new forms of communication. We refined these instruments to align embodied experience with CT exploration.

6 Conclusion

Across our presentation of neurodiverse sensemaking, (C)ADMI-related literature, and the NEWMT co-design process, we highlight how a pluralization of agency and a focus on entanglement can transform both the design and evaluation of wearable musical instruments. Far from "correcting" neurodivergent communication, collectively playable instruments invite neurotypical and neurodivergent individuals alike (i.e. neurodiverse individuals) to question normative assumptions about intention, agency, and collaboration [29]. Through iterative DBR cycles, teachers and students engaged in CT that was deeply embodied, multi-sensory, and relational. Topological modeling and statistical mapping strategies can better accommodate fluid, ongoing sensemaking processes—thus pushing against the reification of body-mind relations. By aligning with neurodiversity and fourth-wave "entanglement HCI," we propose that CADMIs can evolve to promote inclusive, vibrant modes of sensemaking for all learners, rather than reinforcing a single "correct" way of being in the world.

7 Ethical Standards

This study was conducted as part of a university-community research-practice partnership (RPP). All research activities involving human participants, including teachers and students, received approval from the Arizona State University Institutional Review Board. Parental consent and student assent were obtained prior to participation in any workshops, recordings, or data collection activities.

We adopted a neurodiversity-affirming framework, avoiding deficit-based language and prioritizing co-design and agency. No personal or identifying information from youth participants is disclosed in this paper, and images are shared with permission. Researchers took care to ensure that participation was voluntary, inclusive, and sensitive to sensory and social needs.

Acknowledgments

We are especially grateful to the Neurodiversity Education Research Center and its CEO, Dr. Rob Stenson, whose support, collaboration, and advocacy were invaluable to this project. This material is based upon work supported by the National Science Foundation under Grant No. 2122924. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] James Auger. 2013. Speculative design: crafting the speculation. *Digital Creativity* 24, 1 (March 2013), 11–35. https://doi.org/10.1080/14626268.2013.767276

[2] Hugh Aynsley, Tom Mitchell, and Dave Meckin. 2023. Participatory Conceptual Design of Accessible Digital Musical Instruments using Generative AI. In *NIME 2023*.

[3] Sasha Barab. 2022. Design-Based Research: A Methodological Toolkit for Engineering Change. In *The Cambridge Handbook of the Learning Sciences* (3 ed.), R. Keith Sawyer (Ed.). Cambridge University Press, Cambridge, 177–195. https://doi.org/10.1017/9781108888295.012

[4] Karen Barad. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning.* Duke University Press. Google-Books-ID: 4qYorOpfB6EC.

[5] Jane Bennett. 2010. *Vibrant Matter: A Political Ecology of Things.* Duke University Press. https://doi.org/10.1515/9780822391623

[6] CAST. 2025. Universal design for learning (UDL). https://www.cast.org/what-we-do/universal-design-for-learning/

[7] R Chapman. 2021. Neurodiversity and the social ecology of mental functions. *Perspectives on Psychological Science* 16, 6 (2021), 1360–1372. https://doi.org/10.1177/1745691620959833 Number: 6.

[8] Rebecca A. Charlton, Timothy Entecott, Evelina Belova, and Gabrielle Nwaordu. 2021. "It feels like holding back something you need to say": Autistic and Non-Autistic adults accounts of sensory experiences and stimming. *Research in Autism Spectrum Disorder* 89 (2021), 101864. https://doi.org/10.1016/j.rasd.2021.101864

[9] Nicola Davanzo and Federico Avanzini. 2020. A Dimension Space for the Evaluation of Accessible Digital Musical Instruments. (June 2020). https://doi.org/10.5281/ZENODO.4813326 Publisher: Zenodo.

[10] Hanne De Jaegher and Ezequiel Di Paolo. 2007. Participatory sense-making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences* 6, 4 (Dec. 2007), 485–507. https://doi.org/10.1007/s11097-007-9076-9

[11] Agostino Di Scipio. 2003. 'Sound is the interface': from interactive to ecosystemic signal processing. *Organised Sound* 8, 03 (Dec. 2003). https://doi.org/10.1017/S1355771803000244

[12] Corey Ford and Chris Nash. 2020. An Iterative Design 'by proxy' Method for Developing Educational Music Interfaces. In *NIME 2020*.

[13] Francisco J. Varela, Evan Thompson, and Eleanor Rosche. 2017. *The Embodied Mind: Cognitive Science and Human Experience* (2nd ed.. ed.). MIT Press, Cambridge, MA.

[14] Christopher Frauenberger. 2020. Entanglement HCI The Next Wave? *ACM Transactions on Computer-Human Interaction* 27, 1 (Feb. 2020), 1–27. https://doi.org/10.1145/3364998

[15] Emma Frid. 2019. Accessible Digital Musical Instruments—A Review of Musical Interfaces in Inclusive Music Practice. *Multimodal Technologies and Interaction* 3, 3 (July 2019), 57. https://doi.org/10.3390/mti3030057

[16] Emma Frid and Alon Ilsar. 2021. Reimagining (Accessible) Digital Musical Instruments: A Survey on Electronic Music-Making Tools. In *NIME 2021*. PubPub, Shanghai, China. https://doi.org/10.21428/92fbeb44.c37a2370

[17] Eugene T. Gendlin. 1997. *Experiencing and the Creation of Meaning: A Philosophical and Psychological Approach to the Subjective.* Northwestern University Press.

[18] Donna J. Haraway. 2016. *Staying with the Trouble: Making Kin in the Chthulucene.* Duke University Press. Google-Books-ID: ZvDgDAAAQBAJ.

[19] Jacob Harrison and Andrew P McPherson. 2024. Instruments, Ecosystems and Access: ADMIs in the Wild. *Journal of New Music Research* (2024).

[20] Tommi Himberg, Julien Laroche, Romain Bigé, Megan Buchkowski, and Asaf Bachrach. 2018. Coordinated Interpersonal Behaviour in Collective Dance Improvisation: The Aesthetics of Kinaesthetic Togetherness. *Behavioral Sciences* 8, 2 (Feb. 2018), 23. https://doi.org/10.3390/bs8020023

[21] Caroline Hummels and Jelle van Dijk. 2015. Seven Principles to Design for Embodied Sensemaking. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction - TEI '14*. ACM Press, Stanford, California, USA, 21–28. https://doi.org/10.1145/2677199.2680577

[22] James Hutson, Piper Hutson, and Morgan Harper-Nichols. 2024. *Sensemaking and Neuroaesthetics: Neuroarts and the Spectrum of Neurodiverse Experiences.* Springer Nature. Google-Books-ID: UvEGEQAAQBAJ.

[23] Kristina Höök. 2018. *Designing with the Body: Somaesthetic Interaction Design.* The MIT Press, Cambridge, MA.

[24] Balazs Andras Ivanyi, Truls Bendik Tjemsland, and Lloyd May. 2024. Participatory Design of a Collaborative Accessible Digital Musical Interface with Children with Autism Spectrum Condition. In *NIME 2024*.

[25] Balazs Andras Ivanyi, Truls Bendik Tjemsland, Christian Vasileios Tsalidis De Zabala, Lilla Julia Toth, Marcus Alexander Dyrholm, Scott James Naylor, Ann Paradiso, Dwayne Lamb, Jarnail Chudge, Ali Adjorlu, and Stefania Serafin. 2023. DuoRhythmo: Design and remote user experience evaluation (UXE) of a collaborative accessible digital musical interface (CADMI) for people with ALS (PALS). In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems.* ACM, Hamburg Germany, 1–13. https://doi.org/10.1145/3544548.3581285

[26] Robert H Jack, Jacob Harrison, and Andrew P McPherson. 2020. Digital Musical Instruments as Research Products. In *NIME 2020*.

[27] S Kapp, R Steward, L Crane, D Elliott, C Elphick, Elizabeth Pellicano, and G Russell. 2019. 'People should be allowed to do what they like': Autistic adults' views and experiences of stimming. *Autism* 23, 7 (2019), 1782–1792. https://doi.org/10.1177/1362361319829628 Number: 7.

[28] Kim Cascone. 2000. The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music. *Computer Music Journal* 24, 4 (2000).

[29] M. Koro, A. M. Vasquez, C. Reutlinger, and C. McLeod. 2025. Polyphony of (analytical) scores, co-design, and creative methodologies. *International Journal of Art & Design Education* (2025). https://doi.org/10.1111/jade.12583 Advanced online publication.

[30] Travis MacDonald, Barry MacKenzie, and James A Hughes. 2020. SmartDrone: An Aurally Interactive Harmonic Drone.

[31] Erin Manning. 2016. *The Minor Gesture.* Duke University Press. Google-Books-ID: 01gqDAAAQBAJ.

[32] Andrew McMillan and Fabio Morreale. 2024. Occupational Therapy Methods in the Design of Accessible Musical Instruments.

[33] Landon Morrison and Andrew McPherson. 2024. Entangling Entanglement: A Diffractive Dialogue on HCI and Musical Interactions. In *Proceedings of the CHI Conference on Human Factors in Computing Systems.* ACM, Honolulu HI USA, 1–17. https://doi.org/10.1145/3613904.3642171

[34] A Nonnis and N Bryan-Kinns. 2024. Unmasking the power of play through TUI designs. *ACM Transactions on Computer-Human Interaction* 31, 4 (2024), 1–43. https://doi.org/10.1145/3648619 Number: 4.

[35] Nuno Otero, Marc Jansen, Victor Lazzarini, Damian Keller. 2020. Computational thinking in ubiquitous music ecologies. In *Ubiquitous Music Ecologies.* Routledge, London ; New York, 129–153.

[36] Gabrielle Nwaordu and Rebecca A. Charlton. 2024. Repetitive behaviors in Autistic and Non-Autistic adults: Associations with sensory sensitivity and impact on self-efficacy. *Journal of Autism and Development Disorders* 54, 11 (2024), 4081–4090. https://doi.org/10.1007/s10803-023-06133-0 Number: 11.

[37] Michael Nyman. 1999. *Experimental Music: Cage and Beyond.* Cambridge University Press. Google-Books-ID: QEBzEhzAkYwC.

[38] J Kevin O'Regan. 2011. *Why Red Doesn't Sound Like a Bell: Understanding the feel of consciousness.* Oxford University Press, Oxford.

[39] D Pfeiffer. 2001. The conceptualization of disability. In *Exploring theories and expanding methodologies: Where we are and where we need to go?* Research in social science and disability, Vol. 2. Emerald Group Publishing Limited, Leeds, 29–52. https://doi.org/10.1016/S1479-3547(01)80019-1

[40] Zoi A. Philippakos, Emily Howell, and Anthony Pellegrino. 2021. *Design-Based Research in Education: Theory and Applications.* Guilford Publications. Google-Books-ID: 9U0tzgEACAAJ.

[41] M. Pivovarova, C. Reutlinger, A. Vasquez, and S. Thorn. 2025. Towards Co-Creating Neurodiverse Tech Workplaces: Unlocking Potential Through Employer Training. In *American Educational Research Association Annual Meeting*. Denver, CO.

[42] Margaret Price. 2024. *Crip Spacetime: Access, Failure, and Accountability in Academic Life.* Duke University Press, Durham and London.

[43] C. Reutlinger, A. Vasquez, M. Koro, S. Thorn, and M. Pivovarova. 2025. Topological mappings of neurodiverse learning space flows. In *American Educational Research Association Annual Meeting*. Denver, CO.

[44] C. Reutlinger, A. Vasquez, C. McLeod, M. Koro, and D. Amiot. 2024. Composing sensory neurodiverse pedagogies using score analysis. In *American Educational Research Association Annual Meeting*. Philadelphia, PA.

[45] Matthew Rodger, Paul Stapleton, Maarten van Walstijn, Miguel Ortiz, and Laurel Pardue. 2020. What Makes a Good Musical Instrument? A Matter of Processes, Ecologies and Specificities. In *NIME 2020.*

[46] Tara Rodgers. 2010. *Pink Noises: Women on Electronic Music and Sound.* Duke University Press, Durham, NC.

[47] Thecla Schiphorst. 2011. Self-evidence: applying somatic connoisseurship to experience design. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11).* Association for Computing Machinery, New York, NY, USA, 145–160. https://doi.org/10.1145/1979742.1979640

[48] Maxine Sheets-Johnstone. 2011. *The Primacy of Movement.* John Benjamins Publishing. Google-Books-ID: 2EDgXzWMfuwC.

[49] Valerie J. Shute, Chen Sun, and Jodi Asbell-Clarke. 2017. Demystifying computational thinking. *Educational Research Review* 22 (Nov. 2017), 142–158. https://doi.org/10.1016/j.edurev.2017.09.003

[50] Seth Thorn. 2021. Telematic Wearable Music: Remote Ensembles and Inclusive Embodied Education. In *Audio Mostly 2021.* ACM, virtual/Trento Italy, 188–195. https://doi.org/10.1145/3478384.3478386

[51] Seth D. Thorn, Halley Willcox, and Sha Xin Wei. 2020. Processual and Experiential Design in Wearable Music Workshopping. In *Proceedings of the 7th International Conference on Movement and Computing.* ACM, Jersey City/Virtual NJ USA, 1–8. https://doi.org/10.1145/3401956.3404235

[52] Seth D. Thorn and Halley L. Willcox. 2022. Collectively playable wearable music: Practice-situated approaches to participatory relational inquiry. *Wearable Technologies* 3 (2022), e2. https://doi.org/10.1017/wtc.2021.19

[53] Kyriakos Tsoukalas and Ivica Bukvic. 2021. Music Computing and Computational Thinking: A Case Study. In *NIME 2021.* PubPub, Shanghai, China. https://doi.org/10.21428/92fbeb44.1eeb3ada

[54] Kyriakos D Tsoukalas and Ivica Ico Bukvic. 2018. Introducing a K-12 Mechatronic NIME Kit. In *NIME 2018.*

[55] United Nations. 1989. Convention on the Rights of the Child. https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child

[56] Ananí M. Vasquez, Timothy C. Wells, Marina Basu, and Garrett Laroy Johnson. 2022. From Technique to Technicity: Non-Methodological Explorations of Chairs, Neurodiversity, and Schooling. *Reconceptualizing Educational Research Methodology* 13, 3 (Nov. 2022). https://doi.org/10.7577/rerm.5147

[57] Nick Walker. 2021. *Neuroqueer heresies: Notes on the neurodiversity paradigm, autistic empowerment, and postnormal possibilities.* Autonomous Press.

[58] Amanda Williams and Lilly Irani. 2010. Theres Methodology in the Madness: Toward Critical HCI Ethnography. (2010).

[59] Jeannette M Wing. 2006. Computational thinking. *Commun. ACM* 49, 3 (March 2006), 33–35.

[60] Joe Wright. 2020. The Appropriation and Utility of Constrained ADMIs. In *NIME 2020.*

[61] Joe Wright and James Dooley. 2019. On the Inclusivity of Constraint: Creative Appropriation in Instruments for Neurodiverse Children and Young People. In *NIME 2019.*