Reconsidering Precision:
Computational Knitting as a Participatory Design Practice with Neurodivergent Communities

by

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Abstract

This work expands the scope of computational design beyond optimization, advocating for relational, sensory, and process-oriented modes of engagement. The dissertation shows that a participatory process can be used to study the capacity for computational knitting to meet the needs of neurodivergent individuals, thus positioning it as a research tool to study tactility and identity.

Though working with neurodivergent communities, the research reflects on conventional computational design values and priorities, arguing that the notion of precision in computational design should be reconsidered. By challenging these norms, the work proposes design processes to be more responsive to neurodivergent communities' sensory needs. Knitted materials are designed to support a nuanced expression of these needs, as sensory preferences are critical yet often difficult to articulate.

Methodologically, the dissertation is grounded in community-based participatory research and collaborates with disabled adults at Disability Network Washtenaw Monroe Livingston and neurodivergent teenagers at Ann Arbor Academy. The research analyzed how participants responded to machine-knitted objects and how they used knits to express their ideal sensory space. The collected data include extensive participant observation during the art-making workshop, in-depth interviews, and the artworks produced by participants.

Workshops revealed the limitations of prevailing computational design paradigms when applied to participatory and sensory-inclusive design contexts. Tensions emerged when parametrization, computational aesthetics, and outcome-driven approaches encountered the fluid, relational, and evolving conditions of body and mind. The findings suggest that mainstream computational design methods emphasizing precision operate as a double-edged sword in participatory contexts. Precision enables rapid customization and produces diverse tactile variations across scales and interaction modes. However, highly precise and visually resolved artifacts risk appearing as "finished conversations," discouraging intervention, improvisation, and creative interpretation. This aesthetic of technical completeness, coupled with rigid, rule-

based workflows, can constrain responsiveness to lived experience and undermine the openness required for inclusive, human -centered design. Qualitative methods are essential to ensure that designers understand when and where a participant-guided, collaborative design process should take precedence over traditionally privileged methods of machine control and quantitative measurements.

The interdisciplinary approach of this dissertation integrates research methods from fields not typically conversant with one another, i.e., computational knitting and community-based participatory research, also supported by qualitative analysis that situates the research in lived experience. By making tactility the central site of investigation, the research challenges the vision and mobility-centric accessible design approach that dominates architectural practices, adding knowledge about spatial and sensorial practices to disability studies. Furthermore, the research offers a critical reflection on the researcher's role and interrogates how computational design practices actively shape not only material outcomes but also the process of participation and how people make meanings through knitted objects. This work thereby extends computational design beyond optimization, emphasizing relationship, care, and creative agency.

The research also reveals the fuzzy and complex nature of identity-based research, where it is difficult to tie the findings solely to participants' neurodivergence without considering other aspects of their personhood. However, a recurring finding across the study is the desire for greater control over one's sensory environment, whether through fidgeting with the knits or cutting the knits. Nevertheless, the neurodiverse are not the only ones who desire control over their sensory environment, further studies should be done. A broader population stands to benefit from playing a greater role in shaping their sensory environment.

Chapter 1 Introduction

1.1 Brief Overview

This dissertation explains how computational design can develop material systems to support neurodivergent individuals in navigating the built environment, both in terms of sensory experience and social, emotional support. Machine-knitted materials serve as the primary medium, facilitating the communication of sensory preferences within community-based participatory research contexts.

The central research questions are: How can machine-knitted artifacts become part of everyday life to provide meaningful sensory support? How can working with neurodivergent communities in material development orient and reshape computational design practices? And what tools are needed to study individual sensory preferences when such experiences are intimate, situated, and highly context-dependent? Through working with disabled adults in Disability Network and neurodivergent teenagers in Ann Arbor Academy, the research reflects on the limitations of prevailing computational design approaches when applied to participatory and sensory inclusive design.

This dissertation contributes an interdisciplinary research methodology to architectural design practice, integrating computational design, community-based participatory research, and art-based methods, alongside a mixed qualitative and quantitative analytical approach. It also offers a critical reflection on the role of the researcher and on how computational design practices shape the material world.

Machine knitting is uniquely suited to this inquiry. Although it operates through computational control, its material outcomes remain partially unpredictable, revealing the limits of simulation and design precision. At the same time, knitting is deeply embedded in cultural heritage, communal practices, and personal material memory. Together, these qualities position knitted materials as a rich and versatile medium for examining computational design processes, communicating tactility, and fostering relationships.

The findings indicate that mainstream computational design methods, often emphasis scalability, precision, and rule-based logic, function as a double-edged sword in community-

based participatory design. On one hand, computational design enables researchers to generate a wide range of tactile variations across scales, textures, and interaction modes, offering a rich site for exploring design options. On the other hand, highly precise and flawless production risks detachment from everyday lived experience. The technical details and visual completeness of the machine-knitted artifacts are often interpreted as a "finished conversation," leaving community members unsure how to intervene or contribute. Moreover, the aesthetic of perfection risks closing off spaces for improvisation, for making mistakes, and for collective meaning-making. The following chapters elaborate on how computational precision is at the center of the tensions that arise during community engagement.

1.2 Terms Used in the Dissertation

The dissertation frequently uses terms related to research methods and disciplinary approaches, ranging from Computational Design (CD) to Disability Studies and Community-Based Participatory Research (CBPR). many terms used in this dissertation are associate with these fields. Many of the concepts and terms used throughout the dissertation are associated with these fields. The research methods are introduced in greater detail in the following sections and chapters; several key terms are defined here to provide initial context.

Computational Design refers to the design that leverage computational methods, such as parametric modeling, and digital simulation to generate, analyze, and refine design solutions. Rather than producing a single fixed outcome, computational design often explores a range of possible forms or behaviors by manipulating parameters and rules within a computational system (Terzidis 2006). In this dissertation, I also build on scholarship that expands the understanding of computing through engagement with human tacit knowledge and ambiguity. This perspective will be discussed further in the following sections.

Material system is an important concept within computational design. It refers to the interrelationship between materials, fabrication processes, and computational logics that together define how material behavior is generated, controlled, and expressed across scales (Gramazio and Kohler 2008). Material systems are often studied systematically through digital fabrication methods. Within this context, **machine knitting** refers to a design and digital fabrication approach where knits are produced and manipulated with industrial flatbed knitting machine.

Neurodivergence is used as an inclusive, non-pathologizing term to describe variations in cognition, perception, and sensory processing. Neurodivergent individuals in this research are

participants whose sensory and social experiences may differ from neurotypical norms, emphasizing lived experience and context rather than diagnosis or medical categorization (Silberman 2016; Yergeau 2018; Rosqvist et al. 2020). **Sensory support** refers to interventions, material, spatial, or relational, that help individuals perceive, regulate, or communicate sensory experiences (Grace 2019). In this dissertation, sensory support refers to design approaches that expand opportunities for everyone to explore the world and engage in social connection in ways that reflect their unique sensory traits (Lupton and Lipps 2018). This concept is primarily explored through the design of machine-knitted artifacts, which function both as tools for communication and as sites for embodied sensory engagement. **Tactility** refers to the sensory and experiential qualities of touch as engaged through machine-knitted materials. It encompasses the physical properties of the material, such as texture, flexibility, and responsiveness, while also recognizing that tactile experience is relational, situated, and subjective. (Lupton and Lipps 2018; Subramanian 2021; Pallasmaa 2012)

1.3 Negotiating Precision

This dissertation draws on Francesca Hughes's *The Architecture of Error: Matter, Measure, and the Misadventures of Precision* to frame precision not as a neutral technical goal, but as an epistemological commitment that privileges control, stability, and measurability while marginalizing uncertainty and deviation (Hughes 2014). Hughes argues that architectural precision has historically sought to eliminate error, treating variation as failure rather than as a potential source of knowledge. Hughes further critiques the pursuit of what she terms "redundant precision," noting that absolute precision is neither achievable in practice nor suitable with the inherently contingent nature of material behavior.

Complementing this critique, Jack Halberstam's *The Queer Art of Failure* reframes failure not as deficiency but as a productive and subversive practice that challenges dominant norms of success, opening space for alternative ways of knowing and being beyond heteronormative and capitalist logics of achievement (Halberstam 2011). Both Hughes and Halberstam push against narratives that privilege mastery and control, suggesting instead that ambiguity, contingency, and "errors" can be generative.

Building on Hughes and Halberstam's arguments, this dissertation approaches precision as something to be actively negotiated rather than an assumed positive in computational design processes. In this research, precision is reconsidered across four dimensions: community

engagement, workshop structure, the agency of knitted materials, and research evaluation. First, the highly precise computation aesthetic could pose engagement barrier. In computational design processes, precision and computational control enable scalability and repeatability. More importantly, the ability to fine tune each design parameter allows for generating abundant variation. These qualities support customization and offer a wide range of tactile and structural qualities to address highly individualized sensory needs. However, highly calculated design and clearly defined functionality can also constrain hands-on improvisation and playful exploration, limiting participants' sense of design agency. The flawless aesthetic could make research participants feel the objects are valuable artworks, belonging in a museum. Some participant indicated that, "I am afraid I might break it if I play with it too much", which closes many opportunities for deeper engagement.

Second, the open-endedness of instructions within the workshop also affects participant engagement, shaping how individuals interpret, respond to, and interact with the activities designed. Some participants felt constrained or even resistant when instructions were overly fixed or structured as step-by-step guidance, as this limited their sense of design agency. They questioned why they should alter their own art-making routines to accommodate the expectations of an external researcher. However, at the same time, I noticed that leaving a design unfinished or giving open-ended instruction are not necessarily support the design agency. The unfinished product can sometimes signal that the designer is not sincere, or that the work is "casual." When design are open-ended, without clear instructions and specification, participants can feel clueless and unsure the purpose of the engagement, consequently, lose interest quickly. These observations underscore the need to balance open-endedness, highlighting the ongoing challenge of manipulate design to negotiating agency in participatory design

Third, the precision and control did not work well in with soft materials. As Hughes, anthropologist Tim Ingold and many other craft theorist suggest, materials are not passive substances waiting to be shaped, but active participants in the making process (Ingold 2013; Adamson 2018; Sennett 2008; Bryan-Wilson 2017). Materials have their own character, resistances, and tendencies. The knowledge emerges through hands-on engagement with these behaviors rather than through abstract representation alone (Sennett 2008; Pallasmaa 2012). Knitting in computational design is a perfect example to demonstrate Hughes's "redundant precision". No matter how much computational effort are invested in material simulation or

machine control, the knitted structure never fully conforms to its digital model, the yarn always breaks for no reason during the fabrication. During the research workshop, while people appreciate the highly specific and varied knitted objects that support communicating a wide range of tactile qualities, it is precisely the unexpected behaviors of the knit, its stretching, curling, and unraveling, that strongly engaged participants and opened space for meaningful conversation.

Finally, quantitative methods have limitations in evaluating the relevance and impact of the identity-based research. In computational design, design parameters, outcome and functionality are often treated as countable metric, therefore it's easy to measure, compare, and validate. Nevertheless, when research involves complex human beings, such forms of evaluation become insufficient and sometime problematic. Sensory preferences cannot be cleanly isolated, nor can they be solely mapped onto people's neurodivergence, or any identity axis, as they should not be.

Participants' responses to tactile materials were shaped by entangled factors including bodily memory, prior experiences, and the specific environment setting of each workshop. Attempts to abstract these experiences into discrete parameters risk flattening the inherently complex, context-dependent, and fuzzy realities of lived sensory experience. While able to scale, repeated and generalize knowledge remain valuable for communicating research within academic community, they often struggle to account for human behavior as a relational and situated phenomenon. It doesn't mean Participants' preferences are irrational or arbitrary; rather, they reflected a form of situated or "fuzzy" logic (Reiter 2019) in which sensory response emerged through the interplay of material interaction, personal history, and social context. For example, a participant's attraction to knits unravelling was not solely a material preference but was bound up with memories of material repair.

In this light, precision in computational knitting is not a fixed goal but a space to reflect and continuously grapple with: How tightly to guide a workshop, how closely to "measure" participants' response, or how much to leave undefined, allowing ambiguity or "error" to shape the process? As Hughes (2017) argues, error and deviation are not merely flaws to be corrected but critical ways of understanding matter, measure, and the limits of control. By embracing the looseness of functionality, the tolerances of knit structure, the fuzziness of connection between people and materials, the research reconsiders what it means to design for sensory experience

and social support; precision is not simply a metric of success, but a site of negotiating design agency between designer and community participants.

1.4 Expanding Computational Design Through Community-Based Participatory Research, Disability Studies and Shape Grammar

This dissertation does not reject precision or the technological developments it enables. Rather, it examines how conventional assumptions about precision limit how computational design extends beyond the research lab and digitally controlled machinery to engage with diverse lived experiences. When computational design is brought into local communities, new tensions emerge, revealing aspects of the field that can be expanded and improved. To address these limitations, this work draws on theoretical frameworks from community-based participatory research (CBPR), Disability Studies, and Shape Grammar. Together, these perspectives broaden how computational design can be understood, not solely as a tool for achieving precision, rapid prototypes, or design optimization, but as a method for engaging with situated knowledge and the interpretive processes inherent in design practice.

1.4.1 Epistemological Turn through the lenses of Community-Based Participatory Research

Bringing computational design to marginalized communities requires reflection on how knowledge is generated and whose experiences are recognized within the research process. Through the lens of community-based participatory research, this dissertation is grounded in the understanding that knowledge is produced relationally. This means that knowledge about tactility does not pre-exist the interactions, nor is it generated solely by a single expert or method; instead, it emerges through the ongoing interplay of people, materials, and their social context. (Israel et al. 1998; Banks et al. 2013; Wallerstein and Duran 2008). Within this framework, participants' lived experiences and personal reflections are treated as integral forms of knowledge production (Fricker 2007; Le 2024).

This epistemological orientation marks a shift away from dominant rationalist and positivist paradigms within computational design, which often position the researcher as an objective observer to discover patterns embedded in the material world and using that rule to control form. In contrast, this work prioritizes relationship-building, positioning myself, the researcher, as a facilitator who values situated knowledge, practices reflexivity throughout the

process, and accepts uncertainty as an inherent part of the research outcomes. (Cornwall and Jewkes 1995; Wallerstein and Duran 2008).

1.4.2 Disability Studies as Research Methodology

These tensions between computational design process, or quantitative methods, become especially notable when research involves working with disabled and neurodivergent communities, whose bodies and sensory experiences are dynamic, diverse, and often resistant to normative standards. In such contexts, epistemological assumptions grounded in measurability, universality, and repeatability are insufficient and biased. As disability studies scholars have argued, practices that enforce normalcy, whether through medical, social, or technological frameworks, can marginalize difference, erase the rich lived experience and creativity of disable individual (L. J. Davis 1995; C. McGuire 2020; Siebers 2008).

Scholar Tobin Siebers defined disability studies as an academic discipline that examines the meaning and consequences of disability as a social, cultural, and political phenomenon. Siebers argues that disability should not be viewed merely as a medical condition but as an integral part of human diversity that shapes social and cultural practices (Siebers 2008). This critical move is to shift from seeing disability as a medical condition to understanding disability as a social construct. Adapting disability studies as research methodology means, as Minich defined, scrutinize not bodily or mental impairments but the social norms that defined particular attributes as impairments, as well as the social conditions that concentrate stigmatized attributes in a particular population (Minich 2016). In computational design, designers often frame disability as a problem or design constraint to be solved. However, disability can instead be understood as a generative site where designers and researchers explore new design possibilities (Yergeau 2018). Through the lens of disability studies, designers can reconsider what design does and question what is treated as “normal” in the built environment, rather than treating disability studies simply as a field concerned only with disabled people. As Sami Schalk states, one can study disabled people and not be doing critical disability studies, and one can be doing critical disability studies and not be directly studying disabled people (Schalk 2017).

Relational thinking further informs how disability is understood within the research, feminist disability studies understand disability is produced through social, material, and political relations (Kafer 2013; Forlano 2016). Furthermore, feminist disability scholars caution against

treating social barriers as the sole site of intervention, noting that bodily pain, fatigue, and sensory distress are real and cannot be fully resolved through social acceptance alone (Piepzna-Samarasinha 2018; Kafer 2013). From this perspective, disability is experienced in and through relationships, among bodies, technologies, spaces, and institutions, it's never a fixed status. The relational model recognizes that disability is shared, negotiated, and fluid, implicating not only disabled individuals but also their families and communities. By troubling binary distinctions between ability and disability, impairment and access, this methodological framework aligns with feminist disability studies' emphasis on variability, interdependence, and the ongoing negotiation of what it means to be human (Simplican 2017).

1.4.3 Understating Ambiguity in Creative Process Through Shape Grammar

Alongside critically examining the promise of computational control in design, this dissertation builds on scholarship that applies computational design to study human tacit knowledge (Bard et al. 2014; Knight 2015), craft practices (Noel 2020), and the inherent ambiguity of design and art-making processes (Stiny 2006; Knight 2003; Knight and Vardouli 2015). This body of work expands computational design beyond rigid rule-based systems and explores its potential to engage with the variability and unpredictability of human practices. In doing so, it contributes to broader efforts to reorient computational design toward a more situated understanding of design. Building on these contributions, this dissertation further explores how computational design processes can be extended to support meaningful community engagement.

Within computational design, the materials are understood as governed by underlying logics, whether geometric or morphological, that can be identified, abstracted, and controlled through a set of parameters (Gramazio and Kohler 2008; Ahlquist and Menges 2011). It is important to acknowledge that computational design methods have contribute significant innovations in design, architecture and construction. In machine knitting research, abstraction, parameterization and material simulation have enabled building large scale knitted material to experiment new ways way to contract a space. Including knitting bio-inspired structure (Singh and Wang 2016), building digital workflow (Sinke et al. 2022), designing functionally graded structures for material efficiency (Sinke et al. 2023) and structural optimization (Tamke et al. 2021) as well as formal exploration with casting materials (Ng et al. 2020; Popescu et al. 2020). In these projects, scalability, repeatability, and precision are both productive and desirable.

Beyond framing computational design primarily through the use of digital tools, Shape Grammar research has explored how computation can operate within creative processes, specific to form and shape, that are inherently ambiguous and open to multiple interpretations. George Stiny demonstrates how new forms and meanings can arise through the reinterpretation of shapes during the design process. Because shapes can be perceived in multiple ways, the application of rules can generate unexpected configurations, allowing designers to discover new possibilities through iterative reinterpretation (Stiny 2006). Expanding on this view, Terry Knight argues that computation can further engage with, rather than eliminate, the fluidity of visual interpretation that characterizes creative processes (Knight 2003). Knight emphasizes that although computation operates through rules, those rules need not remain fixed. Instead, they can evolve alongside the design process, supporting the capture of emergent patterns, even material behavior, and enabling designers to reinterpret earlier decisions as new goals as ideas developed (Knight 2015; Kamath 2020). In this school of thoughts, computation functions less as a rigid procedural system and more as a generative framework that supports iterative exploration.

By demonstrating how designers can compute with ambiguous visual interpretations, Shape Grammar offers an alternative to models to examine also troubling computing and rules in the creative process. It highlights how computational approaches can support exploratory, nonlinear, and interpretive forms of making. This perspective is particularly relevant when considering how computational design methods might be adapted to better understand and support the creative practices of neurodivergent individuals, whose sensory-driven design processes may involve shifting goals, reinterpretation, and exploration.

Building on this interdisciplinary scholarship, this dissertation embraces the fluidity of identity and the sensory experience of the research participants. Such fluidity challenges conventional notions of measurement and precision and refuses to evaluate tactile engagement or design "success" through fixed metrics or universal standards. With this understanding of computational design, the dissertation reframes computational knitting not as a tool for enforcing strict alignment between fabricated material and its digital model, but as a medium that supports participatory engagement, responsive material exploration, and the co-production of knowledge. Through this approach, computational knitting becomes a method to attend to the dynamic qualities of both humans, materials, and their interaction.

1.5 Machine Knitting as a Research Tool to Explore Tactility

In this research, machine knitting is employed as a research tool to explore tactility and to collaboratively imagine how knitted materials can support neurodivergent individuals' everyday life. The development of novel knitted materials not only contribute to the articulation of participants' sensory experiences but also contributes to computational knitting research by extending its applications beyond conventional domains such as apparel and tensile structural.

Knitted material can be found in built environments to serve various functions, such as decoration, acoustic panel or shelter. When knitting machines enter the field of digital fabrication in the architecture research lab, combined with computational design, it opens various design possibilities, such as knitting interactive surfaces with conductive yarns, using them as a mold to cast concrete, or designing sensory playground (Wicaksono and Paradiso 2020; Ng et al. 2020; Ahlquist 2015). These applications push researchers to imagine knitted material beyond fashion and interior products.

In computational design, complex knitted structures and their dynamic behavior has gain more research interests. Researchers apply simulation techniques to capture complex anisotropic material behaviors (Sinke Baranovskaya et al. 2020; Tekerek et al. 2020), attempting to minimize the gap between digital representation and actual knitted structures. The current state of the art shows the significance of this challenge, where it is still the case that a notable amount of manual intervention, computationally and physically, can be often required (Hörteborn and Zboinska 2021; Sinke Baranovskaya et al. 2020; Ramsgaard Thomsen et al. 2016). Some work in this area leverages the tensile quality of knits, creating a scaffold to house other architectural materials. For example, growing biomaterial to form the structure and casting concrete in or on the surface that brings textile fabrication to support architectural construction (Scott et al. 2022; Popescu et al. 2020; Ng et al. 2020).

When knitting enters the field of building technology, approaches that are largely technology-driven and often focus on its geometrical and structural potential which could strip away the textile's rich social and cultural context. Most of the time, computational design approach toward machine knitting are similar to other means of fabrication, such as 3d printing, where the primary goal is to validate a process that matches a digital model with the fabricated form. This leaves little space to explore knitting's diversity of applications, a wealth of

knowledge in the making, and rich design capacity across fibers, fiber structure, color palettes, and surface qualities.

This research advocates for reducing the emphasis on visual representation, instead, embracing multi-modal design processes that foster a search for unpredictable material behaviors, sensory quality, and social engagement as a feedback mechanism to validate the efficacy of the research itself.

1.5.1 Knitting as Cultural, Social, and Material Practice

Knitting is one of the textile-making techniques that embodies the social and cultural legacies of textile crafting, and its material structure opens unlimited design opportunities. Socially, knitting often provides space for building social connections through communal making and shared material experiences (Carpenter 2012; Gauntlett 2013; Johnson and Wilson 2005). Therefore, many art installations leverage such a collective memory and familiarity toward textiles to connect readily with participants. For example, Ernesto Neto's textile installation, Torus Marco Copula from 2012, intends to address all five senses, allowing for many modes of interpretation and, subsequently, making the artwork more accessible and intriguing to viewers. Culturally, textile crafting invokes self-sufficiency, self-empowerment, and communal experience, as well as a tool for fighting oppression in marginalized communities (Robertson and Vinebaum 2016; Callahan 2005). With the recent rise of *craftivism*, more people are using knitting as a form of participatory politics. For example, *yarn bombing*, also referred to as *guerrilla knitting*, communicates social messages through the colorful adornment of public objects and spaces with knitted blankets and wrappings (Close 2018). Finally, knits are commonly valued for their soft, warm, stretchy, and fuzzy materiality, qualities rarely a part of the conversations in computational design. Within a knit's construction, different fiber specifications multiply differences in stitch structures, producing differences, often surprising, in material behavior – another factor in the unlimited variation for textile applications. Therefore, mixed material, iterative explorations, embracing uncertainties, and recognizing social implications should be considered inextricable to research in textile techniques.

Nevertheless, knitting research in architecture often emphasizes the visual quality of textiles and their geometric potential. Anni Albers, a Bauhaus textile artist, argues that designers should always approach material practice and their inherent capabilities with an unprejudiced

attitude. Albers further claims people often manipulate the material to such an extent that they then deem it a limitation. Rather than a process of exploration, Albers defines this simply as arrogance and flaw (Turner 2018). Therefore, when working with textiles, a medium full of potential regarding its social, cultural, material, and design potential, requires an open-minded capacity to reveal and explore the possibilities that arise with the material system within social contexts. This is often in conflict with the intent of a more technically-driven agenda. To this end, investigating how computational tools can engage in communal making recognizes the capacity of communication and social influence in knitting research in an architectural context.

1.5.2 When Knitting Enters the Field of Building Technology

When textiles enter the domain of building technology, it is often seen as a challenge of material physics and the mathematics of machine code. Simulation and knit programming are common research topics that overlap in research from the field of computer science. The goal of textile simulation is to incorporate the computational techniques of computer graphics with finite element analysis (FEA) with the goal of making photorealistic animations of knits, often used in the film and gaming industries (Veit 2012). Examples show the incorporation of fiber behavior into their computational engines to create visualizations of realistic material behavior.

However, there are limitations to applying this approach in architectural knitting research. First, simulation is computationally expensive, and most examples show a limit in scale for the number of stitches computed. Second, it only simulates stitches with a specific hegemonic fiber in an imaginary perfect condition; the actual knit could perform differently because of other factors, such as the way fibers are twisted or factors of the CNC knitting process. Finally, the image produced by simulation doesn't include the information for fabrication, which is an essential part of the computational design process. Recent research leverages machine learning or data-driven methods to replace FEA which lightens the computing load and incorporates knitting paths into the database. However, this method is still not accurate, lacks a dependable validation process and involves an extensive amount of manual work, such as producing individual knit samples and categorizing them into digital databases (Hofmann et al. 2019; Sinke Baranovskaya et al. 2020; Kaspar et al. 2019).

Another track of research focuses on producing knitting instructions or machine-knitting path-planning from any given 3D geometry. Researchers in computer science have proposed the graph method to analyze a given mesh. A data structure is built to store the information of

machine actions and, subsequently, is capable of producing textured and differentiated surfaces (Narayanan et al. 2018, 2019). However, this track of research would not be considered simulation, but rather a tool for analyzing a 3d mesh based on a fixed set of knitting rules. As an example, yarn is not considered a dynamic or non-rigid material. The method primarily resolves how a static set of stitches would only *lay* or map across a geometry.

In the context of computational design, researchers have developed customized tools to bridge the gap between generic fabric simulation and specific CNC knit fabrication. Mapping tools are used to flatten a given 3D geometry, extrapolate a knit program and integrate with proprietary knitting software, such as M1 PLUS for STOLL and Knit Paint for SHIMA SEIKI. The accepted data format is that of a *coded bitmap*, where each pixel, depending on its color, represents a stitch, machine action or combination of both. Examples include the graded field method proposed by Sinke et al., which produces non-homogeneous panels (Sinke et al. 2022) and the *compas_knit package* created by Popescu et al. to design knitted surfaces for concrete formwork (Popescu et al. 2018, 2021).

Knitting research in computational design demonstrates the development of digital tools focused on manufacturing non-developable surfaces on an architecturally-relevant scale. A common approach utilizes structural analysis to derive individual knit panels. Subsequently, stitches are mapped onto these panels through computational tools that have embedded specific stitch structures and their rules for machine knitting. (Scott et al. 2022; Liu et al. 2021; Popescu et al. 2020; Sinke et al. 2022). For example, tools proposed by Sinke et al. flatten non-developable surfaces and map a pattern onto the surface. Some groups conduct swatch-level material experiments before entering the geometric design. For example, Tan et al. investigate the combination of glass fiber and elastic yarn with the sole focus on testing the knit-ability of glass fiber yarns (Tan et al. 2022).

However, there are several limitations of this track of textile research that could hinder the design possibilities of knitted textiles in an architectural context. The first concern is assuming the stitches are static. These mapping engines see each loop in a fixed dimension and use that information to map the target structure, ignoring the reality that loops can deform when forces are applied, and elongate differently depending on the course- or wale-wise nature of the stresses. Second, examining knits in only their tensile quality produces surfaces void of the voluminous richness inherent in the knitted textile. The simplest example is the curling and

ruffling inherent in a rib-knit textile, ubiquitous in the cuffs and collar of a knitted sweater. Moreover, the resulting material system is enamored for its slickness as a single thin membrane that exhibits the structural purity of doubly curved geometries. While a valuable accomplishment, it overlooks and dissuades the most innate of desires for interaction as would be defined by the textile's simplest of functions to cloth, adorn and serve as forms of individual or collective expression.

1.5.3 Social-Driven Knitting Research in Architecture

Some works engaged with knit textiles in architecture do not solely emphasize the complexity of the textile form; instead, they are driven by interactivity, social engagement, and cultural aspects of soft architecture. Felecia Davis argues that touch can communicate emotions and has been understood as a way of relating bodily responses to an environment. Neglecting the richness of non-verbal responses diminishes the body's communicative possibilities (Davis 2015). Sean Ahlquist works with neurodiverse communities in architectural research, asking textiles to provide a wide range of sensory responsiveness. For neurodivergent communities – often lacking agency in the built environment – an individual's process of discovering the particularities of the textile's sensory stimulation becomes empowerment and communication of what is the nature of a preferential environment (Ahlquist 2020). Both re-examine the overlooked nature of textiles and embed social values into their design framework.

In design practice, Davis uses textiles to communicate memory and storytelling through art installations. This is accomplished by embedding microcontrollers and circuits that enable the knitted surface to transmit an electromagnetic wave that, in turn, transforms the installation into an antenna. The antenna subsequently transmits sounds from the Hill District in Pittsburgh to the installation environment at the MoMA in New York City. The intent is to engage visitors in a conversation on the invisible black history in the United States (F. Davis 2020). In comparison, Ahlquist experiments with playscape environments for children with cognitive differences, installed at venues from educational centers to public plazas, embedding interactive elements such as light, sounds, weights, and inflatables within various knitted surfaces and textures. The wealth of design parameters is meant to recognize the diversity of sensory interests specifically for children with autism spectrum disorder. Ahlquist's work showcases the potential for novel, preferential sensory stimulation to drive beneficial effects in behavioral regulation, communication and social interaction (Ahlquist 2022).

Aligning with the emphasis on interactivity in computationally-derived textiles, Jane Scott integrates bio-responsive materials and wood veneers to explore knitted materials as part of environmentally responsive architectural systems (Scott 2013). In the project Lumen, Sabin et al. apply photo-luminescent and solar-active yarns to utilize color and lighting as a dynamic quality of the knitted structure (Sabin 2018). These projects demonstrate different capacities for research that explore beyond only the complexity of form and the advancement of digital tools. Instead, they investigate social values that can emerge as part of the experiences with and within the knitted material system. This study is situated within this area of computational design practice, with an emphasis on advancing the tactility of the knitted surface as it may enhance the expressive, sensorial, and social experiences of those who engage in the architectural environment.

1.6 Layout of the Dissertation

This dissertation has six chapters. Chapter One introduces the research framework and related works. Chapter Two outlines the research methodology, detailing the methods and the logistics of community engagement workshops. Chapters Three, Four, and Five each examine an aspect of the computational design process and machine knitting that comes into tension with community-engaged practice. And finally, Chapter Six is the conclusion, summarizes the research contribution, and points to future works.

Chapter Two, "*What Exactly Do You Want from Me?": Community-based Participatory Research in Computational Design*, describes the research methodology and the mixed-methods approach, which combines Computational Design, Community-Based Participatory Research (CBPR), and Art-Based Research (ABR) for data collection, alongside qualitative approaches for data analysis. It also discusses my relationship with the community and reflects on my positionality within the research context.

Chapter Three, *"I Want to Put This Inside My Pocket": the Limited of Parameterization*, explores how the scale of knitted artifacts affects community engagement. Participants indicated that smaller pieces, particularly those close to the body, even carried in a pocket, were desirable, as they encourage casual and intimate interaction and more easily stimulate participants' imagination about how the materials could engage with their bodies and become part of their daily lives. This was especially important when the knits served an emotional or comforting function, as subtlety and personal accessibility were key considerations.

While computational knitting in architecture often emphasizes structural capacity, creating large spaces with minimal material, this approach did not resonate with participants. Instead, smaller, intimate scales were perceived as more approachable and engaging, highlighting a tension between the design priorities of computational knitting and the contextual experiences of community participants.

Chapter Four, *"Please Don't Cut the Knit": Negotiating Design Agency between Machine Knitting Material and Scraps*, describes the key point of tension that arose when participants wanted to cut the knits to reshape them according to their own intentions, but I intervened to prevent this because my obsession with maintaining the knitted material as a continuous, single thread. The chapter also collects the collage pieces produced by participants during the sensory-making workshop, along with their reflections on and descriptions of machine-knitted materials. The central argument is that when the knits appeared perfect, flawless, and complete, they tended not to invite conversation or collaboration. The chapter concludes with the reflection that, when engaging with local communities, embracing unpredictability, allowing participants' agency to disrupt perfection, and accepting messiness are crucial for fostering meaningful engagement.

Chapter Five, *Magic Doors: When things go Off-Course*, documents the moments when things went off-plan. The chapter focuses on the Magic Door project initiated by students at Ann Arbor Academy. The project revealed how the students continuously renegotiated what a "magic door" meant each week, and how the collective effort ultimately resulted in a series of individual drawing pieces that talk about different stories. The door installation remained in place for several months before being taken down when the space was repurposed.

The process of making the magic doors stands in contrast to conventional computational design workflows, which often follow predefined goals or rule-based systems that lead to static outcomes. This chapter concludes by suggesting that researchers must remain flexible when engaging with community partners, recognizing that computational design does not always need to produce a static outcome or solution. Instead, it can function as an intermediary process, a means of facilitating dialogue, exploration, and mutual learning within the research context.

This study matters because it demonstrates how computational tools, such as machine knitting, can extend beyond producing highly controlled forms, efficient workflows, or optimized solutions. Computational design can also serve as a means for material exploration

and for engaging with human experience in meaningful ways. By using computational knitting and participatory workshops with neurodivergent communities as a site of inquiry, the research examines how precision is not a neutral or objective goal; it deeply shapes how people interact with the environment and how humans are involved in the research.

The dissertation contributes to a vision of computational design that moves beyond precise execution, leveraging the power of computation to support practices that are flexible, inclusive, and human-centered.

Chapter 2 “What Exactly Do You Want from Me?”: Community-Based Participatory Research in Computational Design

Through the literature reviews, I was already aware that community-based participatory research is rarely straightforward. It requires engaging with multiple forms of uncertainty, uncertainty that arising from uncontrolled environments outside the research lab, from complex social dynamics, and from the diversity of human experiences and ways of being.

The challenges of working with people are not only about navigating interactions “out there.” One of the most difficult aspects of this research was confronting the fact that my personality, assumptions, and values as a human can also cause tension with the participant and shape the research in ways I did not anticipate.

To foreground the realities of this complexity, I begin this dissertation with a conflict with a participant at the Disability Network. Through this tension, I want to offer a sneak-peck of how this participatory work carried on through ongoing negotiation, gradually shifting in shape as the research unfolds.

Jasmine, a regular art class member is a warm and caring presence, often initiating conversations and checking in on others when entering the space. Her straightforward personality brings a candid energy to the group. She would sometimes pull me aside to ask for more details about the research or to offer advice.

During one session, she asked what would come out of these workshops, what the final “product” would be. It was an honest and reasonable question. Yet, like many PhD students navigating uncertainty and self-doubt in the midst of their research, I did not have a clear or neatly packaged answer. I explained that the workshops were meant to help me better understand people’s sensory preferences, which would then inform my design research. I emphasized that there was no predetermined “product”; the process was exploratory, and the community participatory would guild the research development.

My answer, however, seemed to confuse her. Jasmine may have participated in other research collaborate with Disability Network where the workshop was clearly tied to developing

a specific wearable or assistive device, and the participants were expected to provide input toward a concrete end goal.

When I reiterated that the knit artifacts, I brought were intentionally open-ended and that I simply wanted to observe how participants interacted with them, her questions grew more insistent. As she pressed for clarity, I become so nervous, and my maybe sounds dodgy. The more I tried to explain, the more skeptical she seemed about my intentions.

Eventually, Jasmine became visibly upset. She suggested that I was pretending not to have an agenda, that I was withholding information and collecting insights "under a mask." She said she felt clueless about what we were doing, and that without a clear goal the sessions felt like a waste of time. Even though the workshop was designed to create small art pieces or material experiments at the end of each session, Jasmine insisted, "That's not art. That's not the kind of art I would make." Our conversation grew tense, and I quietly signaled Claire to step in. Claire helped ease the tension, but Jasmine stopped engaging with the workshop. She withdrew to a corner and did not complete the "trash diaper" project she was so excited to make at the first place.

This moment of failed communication revealed a deeper tension: What I perceived as an open-ended prompt for play and exploration could instead be interpreted as a hidden agenda, as if the workshop were a trap, designed not for co-creation but for quietly extracting data. It triggered memories for participants who may have had bad experiences associated with this type of research. While I viewed leaving the research outcomes undefined as a way to invite new input and perspectives, to others, the art-based practice was read as a "test" or "assignment", and the undefined goal came across as a lack of transparency, eventually leaving participants with feelings of frustration or mistrust.

Afterward, Claire reassured me that Jasmine's reaction was not unusual, reflecting both her personality and prior experiences. Still, the interaction stayed with me, highlighting the delicate balance between openness and clarity, and reminding me that participatory research is as much about interpersonal relationships as it is about generating knowledge.

I use this moment as a point of departure to highlight the complexities of doing participatory research in the context of computational design. In this interdisciplinary research, local communities are engaged as active partners in the knowledge-making process. Consequently, I draw on a range of methodologies and research frameworks to guide the

development of research questions, shape the relationships between researcher and participants, inform the research design, and structure the analysis.

This chapter will first introduce the community partners and lay out my positionality working with disabled adults and neurodivergent-queer teenagers in Ann Arbor, followed by a discussion of my relationships with both research sites to provide additional context. I then introduce the research questions and explain why integrating Community-Based Participatory Research (CBPR) and Arts-Based Research (ABR) is essential for this project, particularly in fostering meaningful relationships, facilitating accessible communication with neurodivergent communities, supporting ethical data collection, and reflexive qualitative analysis. Finally, I document the research design for both sites, highlighting how the workshop structures were adapted to meet the distinct needs of adult and teen participants.

2.1 Community Partners

My community partners in this research are Disability Network Washtenaw, Monroe, and Livingston, and Ann Arbor Academy. Disability Network is a nonprofit organization run by people with disabilities for people with disabilities. Formerly known as the Ann Arbor Center for Independent Living (AACIL), the organization updated its name in 2023 to better reflect the individuals it serves. It offers personalized services to support disabled adults and youth with housing, employment, and other skills to participate equitably in society. Ann Arbor Academy is a K-12 school that serves what they call "diverse learners," a population of students who need an alternative educational system.

Research participants at Disability Network are identified as disabled adults, and students at Ann Arbor Academy identify themselves as neuro-queer, which means that queer and neurodivergent are both part of their social identity.

Adults in Disability Network and students in Ann Arbor Academy are two very different community partners. Their disability and challenges in life cannot be interchangeable with each other to make a generalized argument about what sensory features can benefit people’s well-being in the built environment. However, they are also similar in a way that they are considered “fragile”, either fragile disabled bodies or fragile minority students that are often seen as victims or someone who needs help to “fit in” with the normative society. A broad comparison between the two groups offers insights into how design strategies can be tailored when working with adults versus teenagers. Table 2-1 below lists the overview of the two research sites.

Research Site	Disability Network	Ann Arbor Academy
Organization type	Nonprofit	K-12 School, Nonprofit
Participants' identities	Disabled Adults	Queer and neurodivergent teenagers
Age range	21-65	15-18
Numbers of participants	8	12
Time spent on relationship building	I attended weekly art studio from 2022 summer - 2023 fall	I host a 50-minute pre-workshop to introduce the research
Time frame for research fieldwork	October and November 2023	February – May 2024
Format of meeting	2-hour art-making workshop bi-weekly, 4 in total	2-hour art-making workshop bi-weekly, 12 in total
Compensation	25 dollar (gift card) per participants per workshop	None
Data collection methods	Video recording	Audio recording

Table 2-1: Overview of two research sites in Ann Arbor.

Participants	pronoun	Brief Description
Disability Network		
Claire	She/Her	Art program director, a wonderful human being.
Susan	She/Her	Susan is from South Asia and always arrives with a bright smile. She enjoys music, drawing, crochet, and dancing. A few years ago, she had a terrible car accident and underwent a leg amputation. She now moves with a prosthetic.
Kelly	She/Her	Kelly always came to class with a caregiver. She was highly engaged in the workshop and eager to share updates from her life with others. She has a movement disorder, which became the central theme of her artwork during the workshop.
Mandy	She/Her	Mandy has been part of the art program since 2020. She has a distinctive artistic style and also exhibits her work in galleries. She is a college student and works as a content curator at a media company. Her disability affects her mobility, movement, and speech.
Jasmine	She/Her	Jasmine is a straightforward and caring person who often offered assistance during the workshop. At one point, we experienced a conflict when she questioned my intentions as an outsider.
Tim	He/Him	Tim is a very sweet person who often brought flowers to Claire during class. He previously attended an art program at a local

		university and is deeply interested in exploring new ways of making. He is a wheelchair user.
Jessy	She/Her	Jessy is very quiet, but her artwork is very colorful and talkative. She attended the first two classes but did not return for the rest.
Caroline	She/Her	Caroline is a long-time member of the art program and an experienced artist. Known for her engaging and talkative nature, she is always eager to participate in discussions.
Felix	They/them	Felix is a quiet and introspective writer and poet; they are sensitivity to environmental sounds and cautiousness around personal boundaries. Despite their reserved personality, Felix has a sharp sense of humor that often catches others by surprise.
Ann Arbor Academy		
Natalie	They/Them	Natalie is the teacher of the leadership class. She is a very kind person and has tremendous patience to learn and grow with her students.
Robin	She/Her	Robin is a school counselor; she checks in with students about their lives from time to time and provides support.
Aspen	She/Her	Addison is a trans woman with beautiful pink hair and colorful nails. Stylish, sassy, and humorous, she's always supportive of her friends.
Skyler	He/Him	Skyler struggles with narcolepsy, which keeps him from attending class regularly. However, whenever he does show up, he brings strong leadership charisma and is an excellent listener.
Murphy	They/ Them	Murphy is a mature teenager who enjoys making scaled models and collecting fossils. Their work reflects both their Arab heritage and feminist views.
Audrey	She/Her	Audrey is stubborn and avoids talking about feelings. She tends to say no to any of my requests or questions. She is very sweet and caring to her friends.
Madison	She/Her	Madison attends nearly every workshop. A natural leader, she's a talented painter and theater tech. Madison thrives in the messiness of art-making and enjoys being adventurous.
Mason	They/ Them	Mason is talkative and always sharing social media memes with the group. They have OCD, and they wear gloves all the time. They are also uncomfortable with people standing behind them.
Ryder	They/ Them	Ryder is a Swifty, very stylish, and very good at water coloring. They like to talk about TV shows and movies and how these media reflect feminist thinking to the group. They are struggling with bipolar disorder.
Bailey	They/ Them	Bailey is sassy and humorous, and whenever she shows up, the atmosphere brightens instantly.

Gina	She/Her	Gina is calm and sensitive to others' emotions. When someone has an emotional breakdown, she knows how to support them without causing further distress.
Brook	She/Her	Brook is energetic and often makes up songs or funny phrases to make everyone laugh. She is also very imaginative; she convinced the whole group to build magic doors as part of the art workshop activities.

Table 2-2: List of all research participants, with assigned pseudonyms, self-identified pronouns, and brief personality description from my observation.

2.2 Positionality

In entering this work that is working with the disabled community in the field of design, I am aware of and constantly grappled with the ableism research tendency when designers engage with disability community with novel technology to solve people's problems. I am aware that technology can be a source of discrimination. Moreover, I recognized my work has elements that overlap the assistive mindset and did not fully break the designer/client relationship in the community-engaged process. Nevertheless, I believe computational design has the potential to design material systems that are tailored to people's needs, either assisting daily activities or bring some fun to life. Besides believing computational design has the potential to extend to the disabled community to broaden its contribution to society, I also align with the belief that improving the design of built space is not just about "adding" disabled people to existing environments to better meet their "needs (Boys 2018). The dissertation is trying to propose a different design practice that does not frame disabled people in limited ways but recognizes they have agency in making space for themselves, and their way of making can contribute to a more inclusive design practice.

Along these lines, despite the access to both research sites already established by my advisor and the people in both sites always welcoming me to their space, I attempted to be careful to discern which spaces were and were not mine to enter. I don't identify myself as disabled physically and mentally, nor queer. Doing this dissertation is the process for me to grapple with my positionality as an outsider to disability network at Ann Arbor Academy. In their social space, I am conscious of my researcher identity. I tend to listen, not comment on their situation or opinion. I always make sure to inform people when I start recording. Nevertheless, the line between my researcher-self and the self that is social and wanting to make friends becomes blurry when I engage with the community longer. I sometimes find myself entering people's intimate social space, whether people are talking about their personal lives or private

medical conditions. Without knowing if this information is intended to be shared with me or not, I try to leave it out in the writing.

While Disability Networks and Ann Arbor Academy are both very inclusive and friendly toward me, I always occupied an outsider position, and my perspective was deeply shaped by the people and friendships I formed during the time I conducted the research.

The year I went to Claire's open studio, I connected with people in the art class through art making. Sometimes, when my research gets stuck, I use the studio to relax, listen to people's life stories, and shift my focus to other stuff. I also participated in an emerging Oreo Club with a group of Oreo enthusiasts. Claire will shop for different Oreo flavors each month and distribute them through the disability network. We pick up the Oreo samplers and meet online to sample different flavors, make Oreo art, and do Oreo quizzes together. I even brought a special Oreo flavor from Taiwan to share with the group.

In AAA, when students do weekly-checking with Robin on what happens in life, I would also join and share some pieces of myself that is not relevant to the research but connect with them as a person. I did not form a deep, long-term friendship with the research participants. Yet I become friends with Claire and Natalie outside of my research life. We meet up for lunch, coffee, or craft day. We would discuss my research and review my manuscript professionally, but most of the time, we would talk about life, family, and relationships and have crafty hangouts. These friendships make me feel closer to Ann Abor, feeling I am not just in this place for an academic degree; I am connected to this place.

In addition to my positionality in the overlapping social worlds in both research sites, this dissertation is also informed by my position as an international student in the United States. As a Taiwanese woman pursuing a graduate degree, I often experience a sense of being an outsider in the United States, yet my position also affords me certain privileges. For instance, my title as a PhD student at the University of Michigan frequently grants me entry into social spaces with relative ease, particularly among groups primarily women and teenagers, who often perceive me as intelligent and non-threatening. Furthermore, my work on machine knitting, a technology that remains largely confined to clothing manufacturing industries and academic environments, positions me with specialized knowledge that is not widely accessible. Additionally, as a non-disabled researcher focusing on disabled communities, I am conscious of the privilege I hold in being able to secure grants, partially due to the perceived social importance of this work.

Considering these privileges, I have taken deliberate steps to mitigate any barriers to participants engaging in my research. I ensure that there are no additional costs for individuals working with me and strive to create an environment where everyone can enjoy the art-making process together. To foster accessibility, I avoid discipline-specific jargon when communicating and be flexible in my research plans when communities want to do otherwise. Ultimately, I aim to sit with the privileges and tensions inherent in my positionality, understanding that these factors profoundly shape how I formulate and approach my research questions.

2.3 Relationship with Disability Network, 2020 – 2023

In the studio, soothing jazz music is in the background, and everyone is working on decorating their plaster cast. Kelly and her caregiver were discussing a piece of fabric she found from a pile of scrap material I brought to the class. Kelly was excited to attach the fabric to the cast, and the caregiver was helping her trim the fabric to the shape. I walked by them and saw she was holding a fabric that I had collected a few years ago in a fabric store sale in Pittsburgh. There is a holy woman printed on the fabric in an array; the background is teal, and the woman wears a red cape, glowing in byzantine blue, and roses around her. I did not know who she was; I just thought this graphic arrangement reminded me of Andy Warhol's "Shot Marilyns," so I grabbed it but never had a chance to use it. I was intrigued by why Kelly was so excited about this fabric, so I approached and asked, "Who is this?" pointing to the woman on the fabric. Kelly said, "This is our lady of Guadalupe. She's Mary, Jesus's mom." Suddenly, there were many questions in my head spinning; first, who is "our?" Kelly lives in Guadalupe. Where is that? And this lady married Jesus's mom? I burst out the question:

Yi Chin: What is this?

Kelly: Like, this is, this is our lady of Guadalupe. She's Mary, Jesus’s mom.

Yi Chin: Wait, she married Jesus’s mom?

Kelly: No, she, you know, Jesus from the Bible?

Yi Chin: Yes, yes.

Kelly: Mary is Jesus's mom.

Yi Chin: Oh, Mary![1]

I did not know that Mary has other titles in different places. I thought maybe this is a branch of religion that believes in an alternative history of Jesus's family and accidentally created this awkward situation. Everyone laughed, and no one felt offended, thank God. "Talking to people" in my fieldwork is not as romantic as I imagined when learning from other researchers' participatory work. There is a lot of self-doubt and hesitation when entering the disability community as an outsider and coming in with a different social and cultural background. Benign miscommunication happened a lot when conducting fieldwork in Disability Network; sometimes, it was inevitably causing conflict and disappointment. Nevertheless, art-making and this warm community soften the awkwardness and tension. We get to know each other more as a person through playing with material and chatting about life.

In September 2023, I received IRB approval to begin ethnographic data collection through art-making workshops in collaboration with the art program at the Disability Network. My relationship with the Disability Network and its art program began in September 2020 when I started my PhD program at the University of Michigan. As a student in a community-engaged classroom, I facilitated collaborations between the university and the organization from 2020 to 2022. When I decided to pursue this research, I further strengthened these connections by participating in the art studio on a weekly basis from 2022 to 2023 to deepen my relationship with the organization and its members. The long team partnership between Disability Network and the University of Michigan paved a smoother path for me to conduct the yearlong observation in the facility and successfully recruit the participants for my research.

I first interacted with the Disability Network in September 2020, the semester I began my PhD program at the University of Michigan. I took the class "Engagement" with Professor Sean Ahlquist, my advisor, in the Architecture school. The class integrates the topics of disability theory and machine knitting to explore the socially oriented design process. In the class, staff in the Disability Network help guide students to comprehend the social model of disability and disability movement. They also hosted workshops to help students develop language to engage with disabled individuals in design collaboration. Looking back from this point, this collaboration deeply shapes the focus of my doctoral research.

[1] Conversation in Disability Network art studio, October 16, 2023.

The U-M students teamed up with DN clients to prototype an architectural intervention that was based on knitted material. The class is remote during the COVID-19 pandemic; therefore, students in class adapt the play-by-mail to communicate with the art program members in a material way. U-M students learned the concept of machine knitting and developed boxes of knitted sensory objects, which they sent to the members of the disability network who signed up for the collaborative art project. Afterward, the recipient will log in to Zoom during class time and show U-M students how they think about the knits and what kind of creative practice they develop based on providing material. U-M students took in the feedback and made another box for the next delivery. The goal of the class is to practice communication with people from very different backgrounds, get design feedback from them, and learn how to involve marginalized communities in the design process. After that semester, the collaboration between U-M and Disability Network continued, where my involvement switched to technical support programming and producing knits for student projects within this collaboration.

As I started to develop my dissertation projects in 2022, I sought permission to participate in the art program at the Disability Network. I wanted to have a deeper relationship with the research site before the research started. I want to talk to people there and understand how the art program operates so that I can decide the best way to do research with them. Claire, the art program director, introduced me to the group the first time I came to the art space in person; some people remembered me from the previous collaboration between U-M and Disability Network, and some people knew me for the first time. Art class attendance dynamic: anyone in the network can register to attend the class; sometimes only one person comes, and sometimes a dozen. There were always new faces in the class. People also do not always come into space at the same time. Participants in the art class are diverse in terms of race, age range, and ability. Some people don't have a visible disability, while some people come as a caregiver. This dynamic group formation also makes my identity as an outside researcher fuzzy.

On the very first day I joined the art program, Claire introduced me to the group, saying that I was a student at U-M and that I made textiles. During that time, installations from the past collaboration were still hanging in the art studio; when people asked about those sculptures, Claire would point to me, saying, "Yi-Chin helped make those, isn't it cool? She had a fancy knitting machine at U-M." Besides these moments, I did not actively introduce myself to the group every week. Since new people always drop into the art class, no one questions my

existence in that space. Claire is the center and the authority of the art studio; her greetings granted me legibility in the space. Sometimes, we introduce ourselves to each other during chitchatting, and after a while, people who regularly would know I am "Yi-Chin" and know each other's names through Claire. Nevertheless, they do not necessarily know I am an outsider, a researcher planning to do research with the Disability Network; in fact, sometimes it is also hard to tell who is a caregiver who is coming together and who is the server receiver of the network.

To signify my role as an observer, in addition to participating in the guided sessions and creating art based on the weekly themes, I began using open studio time to practice my figure drawing skills. During these sessions, I would enter the space and document who was there, what they were wearing, and what they were doing. Most of the time, people were intrigued to see themselves being drawn, which became a meaningful way for me to connect with them. The year I participated in the program as a student allowed me to understand the workshop style that others preferred and helped both myself and others feel comfortable with my presence in the space. This step was imparted for my workshops to run smoothly within a short period.



Figure 2-1: Art studio space at Disability Network with hanging knitted tubes created through collaborations between UM students and Disability Network. Claire rearranges the desks for different purposes across sessions.



Figure 2-2: Materials for different art practices, including acrylic paint, markers, pastels, pencils, brushes, and palettes.



Figure 2-3: One of my works from the guided session, which followed artist Camille Holvoet's practice. Inspired by Holvoet's use of repetition and vibrant color to rework fear and discomfort, participants selected an object they liked or disliked and repeatedly painted it on canvas. I chose dragon fruit, reflecting my longing for its taste and presence in Taiwan.



Figure 2-4: An example of my people-drawing practice in the open studio.



Figure 2-5 Me sketching Mandy's painting on the wall.

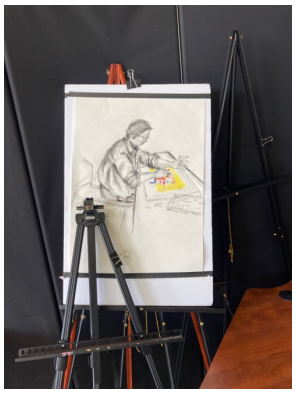


Figure 2-6 A meta moment in the studio: Mandy painting on the wall as I draw her, while Claire sketches me drawing Megan.

2.4 Relationship with Ann Arbor Academy, 2022 – 2024

In a workshop that happened in May, students come in with a relaxing mood. Some students already know where they are going in college, and some are looking forward to the summer vacation. I can tell they are in a good mood. This is the workshop before the final one; I am also in a good mood, thinking this process is going to end soon.

I announced the activity for the day, that we would be working on a mixed material collage to picture what things could be found or what would happen behind the magic door. The students reached the fabric bins and started to play with materials. Some students cut interesting graphics out of cloth, and some put knitted objects on the arm as fashion items. The special thing about the day is that Skyler is in the classroom! Skyler doesn't come to class too often because He cannot sleep properly at night, and that makes going to school during the day hard. Skyler is very funny and full of personality; when he talks, he is the center of the focus in the room. When people all have some material at hand, Skyler starts a discussion: "Here's the thing, Here's the thing. I have, I have, I have a, I have a conversation topic for today. It's really important. So, so if, if shorts are short pants, why aren't pants long shorts? Why don't we call them longs?" Aspen, a sassy girl, responded: "Why? Today is not topic Tuesday." Skyler insisted on delivering her argument:" Wait, but we still have to talk about something. So, I was, I was saying if shorts are called shorts because they're pants but short. Yeah. So why aren't pants called longs? Because it's a shorts, but long. I think we should have shorts and longs and nothing else."

Following this logic, I said, so the short shirt is a T-shirt, and the long shirt is a shirt, which can be confusing too. Skyler agreed that we also need new terminology for shirts too. People started to think about what the opposite letter of “T” would be. Mason said, “A,” cause in

DNA, “A” is opposite to T. So instead of a T-shirt, it would be an A-shirt. Without much disagreement, the group concluded that we use the new words on clothing: T-shirts, A-shirts, longs, and shorts. After this, the conversation moves on to everyone’s favorite bald child (Charlie Brown, Aang, or Stewie Griffin) as people play with knits and make their collage.[2]



Figure 2-7: Skyler initiate the conversation about renaming clothing. During the conversation, they are playing with knits, wearing it on their arm as a fashionable item.

Above is the type of conversation that happens often during art-making workshops at Ann Arbor Academy. The art-making and the random conversation exist in parallel; either one doesn’t seem like a background of the other. They are both important components for crafting a space for friendship and self-expression for this group of students. Through this type of conversation and their artworks, I observed how they related themselves to the bigger world and created a space within it to host their curiosity and imagination.

Ann Arbor Academy (AAA) is a K-12 school that serves what they call "diverse learners," a population of students who need an alternative educational system. The group of students I am working with called themselves HIVE. HIVE was formed by a group of high school students aged between 12-15 who refer to themselves as "Bad Bitches." Since they were aware that the term "bitches" is inappropriate in a school setting, they use the name "bees" to describe themselves, therefore, the official group name is HIVE. The group meets weekly during a *Leadership Class* led by Natalie and Robin. Natalie is the school's multisensory support specialist; besides providing students with emotional, social, and academic support, she focuses

[2] Conversation in Ann Arbor Academy, May 9, 2024.

on making learning spaces comfortable, safe, engaging, and supportive. Robin is the school counselor who provides support in class if needed.

The school's time and space structure making it challenging for me to conduct extensive observation and build relationships as I did in the art program at the Disability Network. I mainly discuss the workshop content and logistics with Natalie during the preparation. I received IRB approval to conduct research workshops with minors in January 2024 and started the workshop in March 2024.

The leadership class operates in an open course structure. Students are encouraged to take the lead in discussions and express what they want to learn, and sometimes, they use this space to express their feelings. For example, they have "Topic Tuesdays," during which students will share something they learned recently, or they are interested in with the group. When engaging with these high school students, I notice I perform differently. The last time I engaged with teenagers was when I was a teenager. My teenager's social anxiety reemerged when I was in a high school class again. I sometimes forget I am an adult in my thirties and subconsciously switch to a self that wants to be cool and looks for acceptance. As I came from a different education system, the culture shock and generation gap inevitably shaped my research analysis. My education was based in Taiwan, and I came to the United States to study a master's program in computational design. To me, high school represents stress and peer pressure. The sole function of high school is to get good grades in college entrance exams. There is no discussion about "identity," most of the students, including me, don't know what gender fluidity is, some students are homophobic, we don't talk about feelings, and we certainly don't have the concept of "mental health."

Here at Ann Arbor Academy, they are all caught up in the relevant social debate about identity. They criticized the Eurocentric history textbook, examined racism in TV shows such as "New Girl" and "Modern Family," and discussed relationships through the TV show "Mr. and Mrs. Smith." Sometimes I need to ask them to explain terms for me, such as what is "cishet" or what is "queer bait." Students are constantly expressing who they are and what they want. They all go through some form of therapy on a regular basis; they know how to support each other and respect boundaries. During their "check-ins," a class ritual that allows students to share their personal news. Students were all ears listening to each other's updates, big or small, heavy or light. For example, there is a student who is going through "becoming-woman stuff," according

to them, who wants to change her name. After she shared the new name, the whole class clapped and celebrated, no question asked. There was another time when a student with ADHD focused on her messy painting experiment and triggered and triggered another student with OCD's anxiety. They acknowledge each other's feelings and eventually make peace with each other. I learned a lot when interacting with them, not just new terms and trending music and TV shows among teenager, but also how to treat each other kindly even though sometimes their comfort space collides with each other.

2.5 Research Questions

The research questions evolved alongside my relationships with both research sites; the participants' feedback continually shaped what questions I asked and how I approached the analysis. The project began with exploring how machine knitting and computational design might create tactile, sensory-rich environments to support neurodivergent individuals. Aiming to identify a range of sensory design that is preferred across the community. Additionally, I investigate what research methods are effective to facilitate collaboration between researchers and community partners in designing novel material system. The findings highlight various design strategies for creating tactile environments and provide insights into the collaboration process.

As the exploration goes on, it became clear that the heart of the research is not just about learning what people like, but about how to collaborate with communities and meaningfully integrate their feedback into computational design practices, especially within a field that often prioritizes data-driven approaches over lived experience.

The central research question of this dissertation is: How can neurodivergence orient and reshape computational design practices? More specifically, I examine why computational approaches matter when designing *with* neurodivergent communities, where values clash when introducing novel material to the community, and how designers navigate collaborations with participants who may not be invested in or may even be skeptical of computational design itself. The aim of this research is to broaden both the methods and priorities of computational design so that the field becomes more responsive to diverse forms of knowledge, including feedback and insights that cannot be reduced to numerical data.

Future work[3] could more intentionally examine questions of control and power within participatory research. For instance, how are the conventional values that are embedded in computational design, such as precision, optimization, and control, negotiated during the collaboration? How is power distributed between the designer-researcher and participants, and how do the power dynamics influence both the research process and outcomes? Attending to these dynamics may also surface tensions between the researcher's design agenda and participants' lived experiences, revealing how collaboration can simultaneously enable and constrain different forms of knowledge and agency.

2.6 Methodology

In order to co-design with disabled and neurodivergent communities, valuing their ways of living as essential knowledge in the design process. I adapted Community-based Participatory research (CBPR) and Art-Based Research (ABR) as guiding framework to shape my research design.

2.6.1 Community-based Participatory Research (CBPR)

Designers and technologists often rely on generalized notions of the "user" or "the human" to guide the functionality or style of a product, which can flatten the richness and diversity of lived experience. Architectural historian Adrian Forty argues that designers often treat "the user" as a homogenous, fictional figure, one without gender, race, or difference, thereby suppressing the complexity of lived experience. Within this framing, users are positioned as passive actors who merely "use" designed objects rather than contribute to the creation. In the context of technological advancement, this abstraction becomes even more pronounced: "users" are increasingly treated as sources of data for training machine intelligence, and as tools for stabilizing relationships between capital and labor (Forty 2000).

STS scholars have similarly critiqued how the category of "the human" remains narrowly defined. Wynter for example, argues that dominant representations of the human center a European, Enlightenment-based masculine ideal, leaving many, women, racialized and colonized people, disabled people, unable to claim full human status (Adams and Weinstein 2020). This restricted understanding of who counts as human, and what counts as human need, becomes

[3] The research question evolved over the course of this study, and future research questions would include examining the control and power within participatory research.

embedded in material artifacts and technological systems, thereby reinforcing normative expectations and marginalizing those who do not fit them (A. McGuire 2010; D'Ignazio and Klein 2020).

In response to these critiques, designers and researchers across social work, design, HCI and disability studies, have increasingly sought ways to involve a wider range of voices in the design process in order to challenge normative assumptions and create technologies that better reflect diverse forms of human experience.

2.6.1.1 Social Work

Community participation is widely recognized as essential for creating environments or services that more accurately reflect people lived experiences. Within the field of social work and public health, CBPR provides a well-established framework for partnering with local communities to shape policies, evaluate programs, and generate knowledge grounded in community priorities (Israel et al. 2005; Wallerstein and Duran 2008). Rooted in decolonizing and constructivist traditions, CBPR aims to empower participants to influence decisions. Key principles including research must align with the community's interests and agenda, emphasizing the importance of qualitative inquiry, and treating qualitative analysis as a means of transforming individual experiences to guide collective practice (Bradbury and Reason 2003).

CBPR also encourages researchers to shift from acting as gatekeepers of knowledge to becoming facilitators. It emphasizes that knowledge produced through community participation should benefit all involved, be actionable, and be shared within the community. This approach enables knowledge-sharing that supports sustainable community development for future generations (Banks et al. 2013).

In addition, CBPR approaches support the formation of advocacy groups and coalitions that elevate marginalized or minority voices in decision-making processes (Checkoway and Richards-Schuster 2003). For example, Israel and colleagues build a long-term partnership with neighborhood in Detroit, where many residents are racial minorities, to support public health advocacy and pursue structural changes aimed at eliminating health disparities (Israel et al. 2010).

2.6.1.2 Design

Participatory methods have also been widely adopted in fields focused on designing products that support everyday life. In product design, the concepts of participatory design (PD) and co-design have become increasingly prominent. Sanders, a design-research scholar, argues that involving users early in the design process enables designers to better understand and respond to people's needs and desires, and can further contribute to social innovation (Sanders and Stappers 2020; Freire et al. 2011; Manzini 2015; Yu 2025). Within this co-creation approach, the role of the design researcher shifts from acting as a translator between designers and users to serving as a facilitator who supports and enables collaborative design processes (Sanders and Stappers 2008).

2.6.1.3 Human–Computer Interaction

In human–computer interaction (HCI), the Scandinavian design tradition emphasizes political, value-driven, and power-sharing approaches to designing technologies and systems. This tradition emerged in response to limitations of user-centered design (UCD), which often prioritizes efficiency, usability, and consumer satisfaction, values that frequently align with commercial purpose rather than with broader social concerns (Bødker 2006; Bødker and Kyng 2018). Building on these critiques, many HCI researchers now adopt participatory design as a framework for examining the ethics, accessibility, and social implications of technological products, with particular attention to people's everyday lives and diverse ways of engaging with technology (Bratteteig and Wagner 2014; Vines et al. 2013; Le Dantec and Fox 2015).

2.6.1.4 Disability Studies

Participatory methods have also been widely applied in research engaging disability and neurodivergent communities (Bennett and Rosner 2019; Costanza-Chock 2020). These approaches include simulation exercises guided by community members (Burgstahler and Doe 2004; Gaudion et al. 2014; Metatla and Cullen 2018; Silverman et al. 2018) and co-design sessions that invite disabled or neurodivergent individuals to serve as design partners, particularly in studies seeking to understand autistic children's experiences with technological devices (Frauenberger et al. 2017; Spiel et al. 2017).

Building on these methodological approaches, researchers in design studies further emphasize the value of tangible and material forms of collaboration. Such practices enable

disability communities not only to contribute feedback but to actively take up design roles, shaping spaces that align with their bodies and everyday social contexts (Luck 2018; Hamraie 2017). Hendren argues that participation from disability communities has the potential to unmake and remake everyday tools and environments (Hendren 2020). Through a case study of the Adaptive Design Association, Hendren highlights how technologies can be tailored to individuals and significantly enhance daily life. Yet, she also stresses that technology alone cannot drive fundamental change; meaningful impact requires social support systems and sustainable infrastructures that allow such designs to flourish.

Through participatory design processes, the involvement of disabled communities introduces diverse embodied experiences. Because these embodiments often challenge the dominant assumptions and values embedded in computational design, they open space for new design method and critical reflection. Ultimately, collaboration between designers and communities can generate fresh opportunities to craft spaces and technologies that more effectively support non-normative bodies.

Drawing from above literature, I attempt to practice the CBPR principle in my research fieldwork. I position both myself and the knitting machine as "instruments" that facilitate the community's creation of sensory spaces. I designed and fabricated a range of sensory knits as speculative probes and offered these materials to community partners as part of their art-making practices. By observing how participants used the knits, the preferences they expressed, and the social dynamics that emerged in the process, I reflected what aspect of CBPR are useful in the context of computational design and how these encounters reveal the limitations of computational approaches when serving disabled and neurodivergent communities.

I also entered each community context with care. I asked for permission to join existing routines, spending time learning the rhythms of art classes and adapting workshop structures to align with formats participants were already comfortable with. Because both research sites use art-making and crafting as central modes of self-expression, art-making functioned as a shared language. I used it to communicate my research agenda and as a tool for envisioning a sensory-rich space.

Throughout the process, I regularly checked in with community members to understand how I could better facilitate activities or adjust the process to meet their needs. When tensions emerged between participants' preferences and my research agenda, I engaged participants

directly in conversation to explore possible adjustments and consult with the community organizer for further support. This ongoing communication mirrors core social work values of transparency, shared decision-making, and responsiveness to participants needs.

2.6.2 Art-based Research (ABR)

Art-making plays a central role in engaging and communicating with participants in both research sites. Art-making culture is a common interest in both the art programs in Disability Network and Ann Arbor Academy, where crafting and art-making connect the members and serve as a form of therapy. ABR is a transdisciplinary approach to knowledge-building that integrates creative art within the research process (Leavy 2019). In ABR, art is regarded as a "way" of knowing rather than merely an object or content (Manning 2016). Researchers in ABR acknowledge art's capacity to convey truths (Barone and Eisner 2011) and to encompass diverse ways of knowing, including sensory, kinesthetic, and imaginative modes (Gerber et al. 2012). In this research, I apply ABR guidelines to collect and analyze various forms of data, valuing the different ways that participants express and understand their experiences.

This approach also addresses a gap in architecture and design, where the field's ocular-centric tradition often overlooks the sensory cues that are essential for people to navigate and understand built environments. Moreover, current computational design processes rely heavily on control through digital devices, limiting opportunities for broader social engagement and diverse forms of expression. Therefore, diversifying the language of design and research processes can help break down barriers to professionalized knowledge and challenge standards of creativity and aesthetics. By embracing more tangible, material forms of collaboration, designers can allow more people to become the role of designers, creating spaces that suit their bodies and embedding design within their social contexts.

With these in mind, I designed art-making workshops to gather insights into three spatial design elements: texture, geometry, and the relationship between body and space. The following sections will elaborate on the structure and design details of the art-making workshops.

2.6.3 Qualitative Analysis

After each art-making workshop, I gathered multiple forms of material: video recordings at the Disability Network site, audio recordings at Ann Arbor Academy, my observational field notes, photographs from the sessions, and the artworks created by participants. Once the

workshops concluded, I transcribed all recordings and wrote analytic notes as I review the transcripts and examined the visual materials.

For the analysis, I intentionally adopted a qualitative and non-coding approach. I chose not to apply coding methods because our conversations were not structured interviews, and participants' expressions did not follow predictable or repeatable patterns. Detaching their words from context and placing them into discrete categories would fail to capture the richness and complexity of the situations. As Pierre argues (2014), coding assumes that data exist independently in the world, waiting to be found, collected, and breaking down to different part to analyzed and generate a solution (St. Pierre and Jackson 2014). Such a method does not align with the community's communication style, and the improvisational nature of art making process.

Along the similar line, Rosiek and Heffernan (2014) note that coding is inadequate for analyzing socially produced silences (Rosiek and Heffernan 2014). This is especially important consideration in my work, where non-verbal cues constitute a significant part of communication with community members. As one caregiver explained, when an autistic child stands at a distance and does not engage with the knitted material, it does not necessarily indicate they are not interested; physical touching and verbal affirmation are not the only ways to signal preference. Understanding these preferences requires spending time with participants, observing, and engaging with them in context to appreciate how they express interest and make choices. Brinkmann (2014) further emphasizes that research cannot be separated from life; there is no rigid boundary between lived experience, research, or theory, because research itself is part of the ongoing process of life (Brinkmann 2014).

The participants I worked with, like all people, are complex and possess multiple, context-dependent identities. While the research focused on neurodivergence and sensory preferences, their behaviors, emotions, and social interactions cannot be neatly categorized or reduced to isolated traits. By adopting a non-coding, reflexive approach, I tried to attend to participants' words, actions, and silences in context, supporting relational meaning-making over rigid, quantitative categories. This method allowed the research to honor the richness of individual and collective experience while remaining aligned with the principles of participatory, community-centered practice.

With these considerations in mind, I engaged in reflexive thematic analysis to identify patterns that emerged across interactions and to make sense of moments that initially appeared unrelated or situational (Hesse-Biber and Leavy 2004; Floersch et al. 2010; Wodak and Meyer 2009; Staller 2015). This flexible, iterative method allowed me to attend to the contextual nature of participants' sensory expressions and interpersonal dynamics, aligning with participatory and social work traditions that prioritize relational meaning-making over fixed, categorical coding practices.

In my writing, I continuously grouped and regrouped the material to think what arguments this dissertation could meaningfully support. I experimented with several different ways of organizing the stories, either by place, by workshop activities, by knitted structures, or by textile attributes. Yet I found it difficult to sort these narratives into discrete categories. Many stories contained multiple layers of meaning and could be read from several angles at once. For example, Mandy's drawing and Susan's plaster casting reflect very different sensory preferences. Mandy enjoys rough, rubbery surfaces, while Susan prefers soft and fluffy textures. However, both stories illustrate how family members and shared activities form an inextricable part of each person's sensory environment. These instances show that coding may separate words or events from their relational and contextual meanings.

I was not alone in the data analysis process. Throughout the analysis and writing phases, I regularly checked in with community organizers Claire and Natalie to confirm details, share my thought on the project, and discuss how the stories resonated with their experiences. These conversations and friendship fundamentally shaped how I read the data and helped me remain accountable to the community.

Although this dissertation set out to explore the relationship between neurodivergence and knitted material, particularly to understand how we might design sensory-inclusive environments, the identity-focused research agenda led me into close collaboration with the Disability Network and Ann Arbor Academy. At times, participants explicitly told me that a particular knit resonated with them because of their disability or their unique sensory preferences. However, I also witnessed many moments in which their identities as disabled, neurodivergent, or queer were not at the forefront of their decision-making, including decisions related to sensory experience. In these moments, I analyzed their preferences in relation to the

broader context: our conversations, the social dynamics in the room, and the interactions between participants and their environment.

For example, one workshop at the Disability Network overlapped with Halloween spirit, and the festive atmosphere shaped participants' choices as much as their sensory preferences. While some community members used body casting to tell stories about how disability shaped their perception of the world, others created casts that simply echoed the season's playful spirit. In another instance, two students with very different thresholds toward environmental stimulus, one with ADHD who is enthusiastic and exploratory, and another with OCD who felt anxious about messy environment, got into a conflict during a shared art-making activity when paints were spilled everywhere. While I could read this conflict as a clash because one is sensory seeker, one is avoidance, my presence in the classroom also allowed me to see it as part of a larger pattern of teenagers' group dynamics, shaped by social relationships, and personality.

These moments remind me that sensory experience cannot be reduced to medical diagnosis and that identity does not operate as a fixed indicator of preference or behavior. While the research focus may be on the sensory profiles of neurodivergent individuals, their full personhood, shaped by complex, intersecting aspects of identity and experience, should be considered as an integral part of the research. Sensory preferences are not isolated phenomena it is deeply embedded within broader social, cultural, and lived experience. Therefore, it is not possible or appropriate to isolate one human sense and one axis of identity to analyze their relationship.

Therefore, non-coding qualitative analysis and reflexive writing become essential tools in this research. They allow me to grapple with complexity, attend to context, and remain accountable to participants lived experiences rather than forcing their stories to achieve my research agenda. Through this reflexive approach, the research becomes not just a study of neurodivergence and materiality, but a practice of staying attuned to the multiple, shifting factors that shape how people engage with sensory spaces, and eventually, all these factors shape how I structure the following chapters.

2.7 Research Design – pARTicipatory Workshops

I designed art-making workshops, advertise as "pARTicipatory Workshops" in both research site to collect primary data from two research sites. Participants at Disability Network are skilled in self-expression through art, while high school students at AAA engage in regular

crafting sessions as part of their educational curriculums. Therefore, art-making serves as an appropriate research tool to explore individuals' sensory profiles in a tangible, material way. Additionally, it acts as an effective medium for communicating complex and unfamiliar concepts to people outside academia, encouraging the incorporation of various media and materials.

Through art-making workshops, I attempt to understand how the relationship with the body, social identity, and environment shape their senses and further impact how they make space for themselves. The data collected included participants' artworks, their making process, and the conversation during the workshop. The data analysis method includes visual analysis of participants' artwork, the thematic analysis of the making process, and the conversation. The workshop plan changed as participants responded, they informed me of the direction in which they wanted this to proceed; therefore, the workshops were the result of constant negotiation. The workshops look different in the two research sites, yet they are still trying to respond to my initial inquiry about how people make space for themselves. I will lay out the implementation details of the art-making workshop in both research sites.

2.7.1 Space and Seating Arrangement

Space and seating arrangement influences the social dynamic in both sites. In Disability Network, the art studio is in a garage space; it is spacious and has a high ceiling. The seats are arranged in a circle, and each person has roughly five feet of working space. The art studio was equipped with all sorts of art supplies; participant all had their go-to medium; some people used acrylic paint, and some liked a pestle. They did not use the art supplies I brought; they only used materials related to plaster casting. People often sit in their regular settings and walk around when they need to supply. Some people in this group are shy and sensitive to noise; they are often very quiet and focused. Conversation did happen between participants, but not as much. Claire is often the center of conversations. She will walk around to see whether people need her assistance and chat with people about their week. Oftentimes, she will announce to the group calling attention to someone’s awesome work, and then the rest will chime in to compliment them or make other conversation.

The classroom space in Ann Arbor Academy is a lot smaller than Disability Network. There are two 5-foot-wide desks and six chairs in the room. When everyone is seated, they cannot easily walk around without asking others to stand up. Students always sit in a circle, as shown in Figure 2-8. The smaller space makes the social interaction more intimate. When the

weather was nice, the whole class moved outdoors. When working outdoors, students ran around, played with swings, and hung out with other students who were having activities outside.

For these students, an art-making workshop is more like a background to contain social interaction. During the class, they chatted about school, classmates, and opinions on TV shows and joked around. Sometimes, the main focus is chatting with their friend, and the drawing is the medium that keeps their hand busy; sometimes, I feel chatting is the background of the work they are focused on. While in Disability Network, most of the work is independent, with people helping each other, but not necessarily having intimate life check-ins, more like small talk.

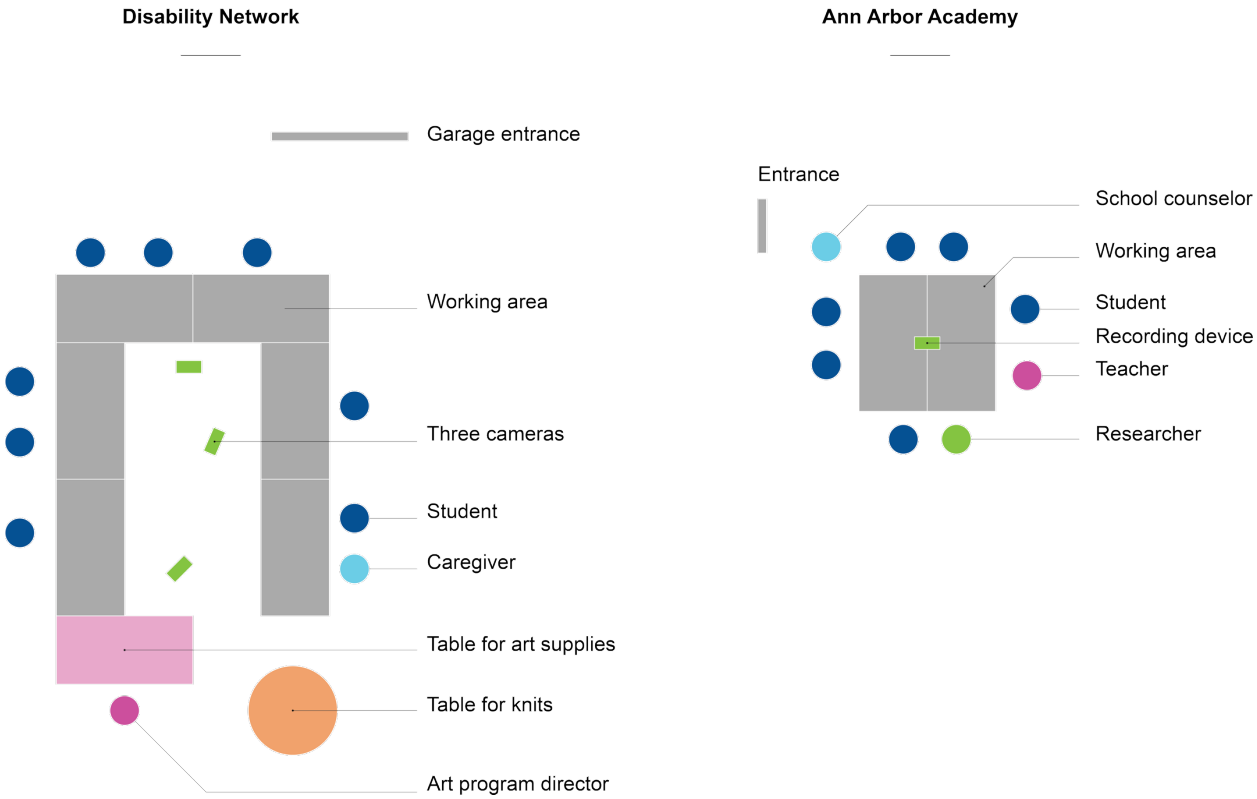


Figure 2-8: Seating arrangement for art-making workshops in each research site.

2.7.2 Participants background and attendance

The participants in the Disability Network are all adults. They are all part of the disability network community. Their disability condition is all different; some have visible physical challenges, and some do not. I did not ask about their condition; I only knew when people wanted to share. Registration is needed to attend this workshop; the maximum number is 12 people. I discussed the compensation of the workshop participants with the director of the

Disability Network. We agreed to provide 25 dollars for each section, and we will hand it out as a 100 dollars gift card at the end of the final section as an incentive for continuous participation. Considering the context of the art program, we agreed to provide gift cards from art stores. Participants can choose from Joan, Michael's, and Blicks. Ten people signed up for the workshop through their weekly newsletter. In the first workshop, only eight people showed up, and two people dropped out halfway.

As the art-making workshop became part of the class material in AAA, I provided all the material yet did not pay students as I did in the disability Network. Attendances of the workshop in AAA are not consistent due to the school's course system. There were usually three to six students come to class every time, but not the same person. Partly because this class is an elective, some students may switch classes before the workshop ends. There are also some instances in which students have a hard time coming to class because of their challenging conditions. After fourteen workshops, I engaged with 12 students across 14 workshops. Students in this group identified themselves as queer. Conditions in the group ranged from Autism Spectrum Disorder, Bipolar Disorder, Fetal Alcohol Syndrome, Attention-deficit/hyperactivity Disorder (ADHD), and obsessive-compulsive disorder (OCD).

2.7.3 Timeframe and Schedule

In the Disability Network, the workshops are embedded in the guided art class and alternates with the art program's original schedule. This way, people who did not sign up for the art-making workshop can still come every other week for their art practice. The art class lasts 2 hours each time, which is plenty enough for people to finish their work. Most of the day, people forget about time when making art, and Claire needs to remind them it's time to clean up the space and warp up the work.

For the AAA, the class duration for high school is 50 minutes; Students often come to different classes and often need 5-10 minutes to settle in. And the 5-10 minutes before the class ends, they will start to agitate, clean up, and pack bags, so the solid working hours were around 30-40 minutes. This significantly changes the workshop plan. Originally, I proposed 6 fifty-minute sections, and we ended up taking 14 sections to finish the whole process.

	Disability Network	**Ann Arbor Academy**

Relationship building	2022 Summer – 2023 Fall	Formal introduction on 2/14/2024
Module 1 – Identity	10/2 2023 - Body casting	2/28 2024 - Body casting
		2/29 2024 - Body casting
Module 2 - Sensory profile	10/16 2023 - Decorating the casts	3/13 - Decorating the cast
		3/14 - Decorating the cast
Module 3 – Narrative	10/30/2023 – Mind map and collage	4/3/2024 - Magic door
		4/4/2024 - Magic door
		4/17/2024 - Magic door
		4/18/2024 - Magic door
Module 4 – Reflection	University lab visits and in depth on-one-on interview	5/2 Material collage
		5/9 Material collage
		5/16 Install the magic door

Table 2-3: the table shows the difference of workshop time frame and theme between two research sites.

2.7.4 Data Collection

I set up three cameras in the art studio space in Disability Network to capture people's making process, as shown in Figure 2-9. This video and audio are only for data analyses; I transcribed all the conversations and showed some in this dissertation to explain the context but didn't share the recording with other people other than myself. I also took photos during the workshop and documented their artwork. After the four workshops ended, I came back to Disability Network during the open studio to follow up with some participants who needed more working time and some people I did not get to talk to too much during the workshop.

Whereas in Ann Arbor Academy, some people in the group don't want their photo to be taken, and the existence of cameras would discourage intimate conversation and regular check-ins in the class. Therefore, I record the audio with my phone. This recording is only for data analyses; I transcribed all the conversations and used conversation in this dissertation to explain the context, but I won't share the recording with people other than myself. I took some photos during the workshop with the student's consent to capture the interesting moments and document work-in-progress. Since I shouldn't interact with those students after the research, I did not visit the high school after the workshop officially ended.



Figure 2-9: Cameras setup during art making workshop in Disability Network.

2.7.5 Workshop Activities

The workshops were designed to understand and communicate what sensory space means to them and how knitted materials could become part of their daily sensory experiences. In both sites, I started with body molding with plater rolls as an interesting activity for us to get to know each other and share our body experience in a material way. In this workshop, participants chose a body part to cast, and we had a round discussion on their design process. In the following workshop, they used paints and soft materials, including machine-knitted pieces, scrap fabric, and various types of yarns, as shown in Figure 2-10 and Figure 2-11, to decorate their casts. Through decoration, I want to know how they relate their body to the larger built environment, their cultural background, or their political identity. People love this workshop a lot on both sites, and it is a good start to relationship building.

After body casting, the workshops go in a very different direction. In the Disability Network, we move on to discuss the narratives behind their comfort sensory spaces in the third workshop. I wanted to learn more context about their sensory space, who else might be involved in these spaces, or what activities could take place there. Some participants used dioramas to depict their spaces, while others created mind maps combining text and graphics to express the details of their comfort spaces. During the workshops, participants expressed interest in the machine knitting process and requested a visit to the knitting lab at U-M. Therefore, in the final workshop, we gathered at U-M for a tour of the knitting lab and conducted one-on-one, open-structured interviews about their experiences in the workshop.

Meanwhile, in the AAA, students enjoyed the plaster casting and asked if they could continue casting in the following sessions. A student asks whether they can plaster a door; after that, the whole class seconds the idea and is very excited about it. Some people said they wanted

to make a magic door that goes somewhere unknown, one said they wanted to make a secret door, one said a door to a map, one said a door to sounding fun, and one said maybe just a fake handle on the wall. After the discussion, we agreed on building magic doors collectively, and they could all picture what would be appended by making an independent mixed-media collage. Most importantly, they can cast door handles at the school or use any fun texture in the facility to decorate the magic door.



Figure 2-10: The scrap soft materials and art supplies I brought to the workshops.



Figure 2-11: The knits I brought to the workshops.

This chapter outlined the research methodology, describing both the methods and the logistics of the community engagement workshops. I have detailed how these approaches were shaped through collaboration with participants, community organizers, and the physical space that the workshop took place. The following three chapters present the stories gathered during fieldwork and the reflection that emerged through this participatory process. Together, these narratives both respond to and complicate my research questions, at times revealing tensions between computational design practices and the realities of community-engaged work.

Chapter 3 “I Want to Put This Inside My Pocket”: The Limits of Parameterization

In exploring the tactile qualities that shape an ideal sensory space for neurodivergent individuals, one theme consistently emerged: people seek spaces where they feel supported. Participants described supportive environments not only through textures or materials, but through the activities and relationships that help them feel peaceful, including engaging in a hobby, being with people who care for them, or touching a familiar texture tied to childhood memories. Participants’ stories revealed that neurodivergence or disability, while an important part of their identity, does not always the sole factors determine what they need in a overwhelming moments. Additionally, knitted materials, central to my own research practice, are not always present or required. What matters most is the felt sense of safety, grounding, and connection. This information undermined the initial research plan, which wanted to explore how knitting material supports nondivergence.

Nevertheless, understanding what support means to each participant still points toward valuable design strategies. Their stories reveal both how community-engaged workshops might be structured better and what design features matter for sensory supportive environment. One recurring design parameter across their experiences was scale. Small knits allowed for casual interaction, could be passed easily from person to person, brought close to the body, and easily manipulated. These findings stand in contrast to common assumptions in computational design in architecture as a field, where support is often imagined through strength, stability, or increased scale, qualities that position care as something large and from outside. Recognizing this discrepancy has pushed me to reflect on how design practices can easily overlook the subtle, intimate forms of care that people actually seek when comes to sensory supports.

This chapter begins by outlining its central argument: sensory spaces are not defined by a single object or material, but by a collection of relationships, between people, activities, memories, texture, and moments of grounding. Understanding these relational qualities, and especially the role of scale, can guide how we design for neurodivergence.

The chapter unfolds through four groups stories organized around the idea of supportive space. The first section focuses on support that extends beyond any physical objects, showing how sensory spaces emerge from networks of people and activities that collectively create safety and comfort. The second part explores how knitted materials can blended into the background, quietly supporting and grounding people without demanding attention. The third section turns to objects that ease social anxiety in public. The fourth story examines knits that transport people to different times or places, using memory and imagination to create a peaceful controllable space.

The chapter concludes by returning to computational design. Here, I argue that insights from community-engaged sensory research highlight scale and portability as a critical factor, and that bigger is not inherently better. Instead, attending to forms of support that are small, intimate, and personally meaningful may open new pathways for designing sensory technologies that resonate with how people care for themselves and one another.

3.1 Sensory Space Holds a Collection of Relationships

In the third workshops at the Disability Network, we centered the activities on storytelling. I invited participants to use any medium they like to describe a sensory space that brings them joy and peace. The responses were very diverse: Caroline painted a quiet, serene room; Susan, Mandy, and Kelly created mind maps collecting all the elements that come together to construct a joyful space; Tim built a small diorama; and Felix, listed the criteria of an envisioned ergonomic indoor hammock.

During the workshop, I encouraged participants to incorporate knitted materials or fabric scraps into their creations, however, knitted materials I brought were rarely central to the sensory spaces they described. This presented a challenge for me as I reflected on what these insights mean for my knitting-centered research. Yet it also revealed something essential: a sensory-friendly space is not defined solely by material qualities, but by the context and relationships that make someone feel grounded. Materials certainly play a role, but their significance depends on the situation and the person's needs. Mandy's mind map offers a clear example of how activities and people rather than objects alone, can structure a sensory space.

In Mandy's mind map Figure 3-1, she began by drawing the activities she enjoys at the top row, including puzzles, reading on an iPad, horseback riding, and cycling. For each activity, she shared details about why she liked it and what she felt while engaging in it. Mandy also

noted certain textures and sensory qualities that enhance her experiences, for example, she enjoys the sticky, grippy pattern on her riding pants for horseback riding.

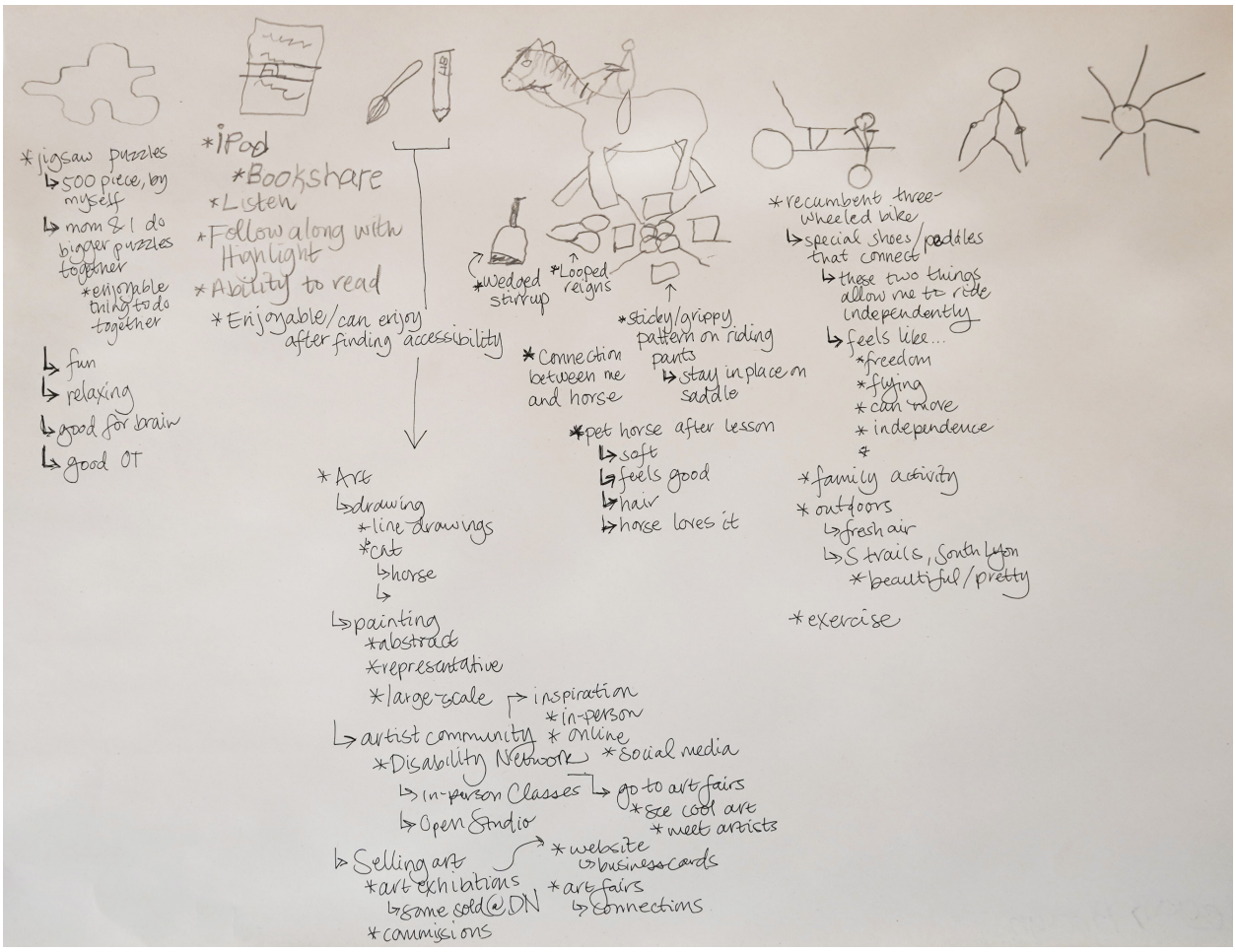


Figure 3-1: Mandy's mind map for an ideal sensory space.

While Mandy's sensory space emerged from the activities that bring her joy, other participants oriented their sensory experiences around specific physical spaces. Caroline, for example, created a painting describing her imaginary sensory space. that is a space has warm color and a cozy bed, with a pet waiting for her return home, Figure 3-2.

Similarly, Kelly centered her sensory space in her living room. Around living room, she mapped out the activities she does there, watching a TV show about yetis with her mother, having snacks, creating diamond art, and participating in Bible study, praise and worship Figure 3-3. She noted that a pink knit reminded her of the living room couch, but not for its texture, just for the color. So, she placed the knit next to her mind map and glued the thread onto the couch represent her pink couch.



Figure 3-2: Caroline's mind map for an ideal sensory space.



Figure 3-3: Kelly's mind map for an ideal sensory space, with a pink unraveling knit by the side as a reference for the couch color.

In this exercise, Felix created a list of things they enjoy, many of which were connected to textiles: an indoor hammock that can hug the body, a neck pillow that offers support, Figure 3-4. They also included a few practical gadgets that make daily life easier, such as a storage pouch within easy reach of their desk and a pulley system that could raise and lower the hammock. Their ideal sensory space is one filled with soft materials that support the body and remain accessible. Felix also selected two knitted swatches to indicate the materials they would prefer for the hammock. One on the right, with more surface texture, which they imagined

positioning near where the hands would rest, and a stretchy black knit, in the bottom, that could form the main body of the hammock.

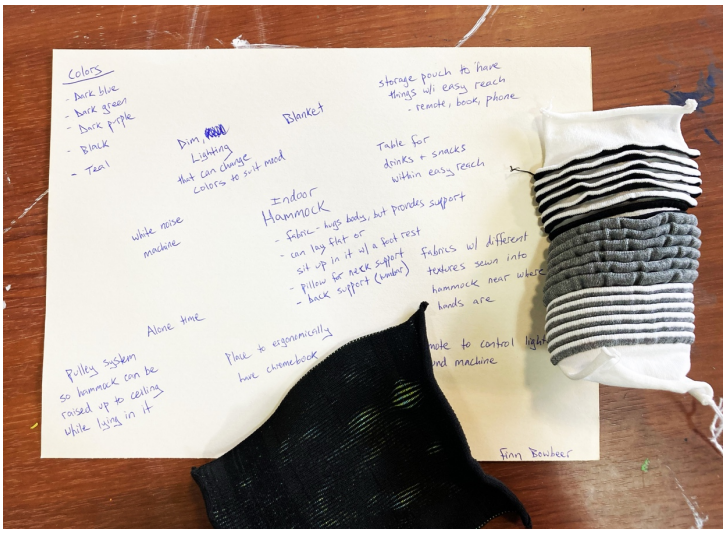


Figure 3-4: Felix's mind map for an ideal sensory space with knits placed by the side for reference.

While Felix's sensory space centered on actual objects they want to better support their everyday life; Susan's approach revealed a very different aspect of sensory space. Susan's mind maps were shaped by her life journey, and she generously talked me through each one, adding context that helped me understand the meanings behind her drawings One map began with a tree representing the start of her life, the left most drawing in Figure 3-5 . Branching out from it were a range of emotions, including uncertainty, anger and loneliness, alongside this emotion, there are friends and family help her transformed difficult emotions into something positive.

In another mind map, the middle drawing in Figure 3-5, the center was her home, surrounded by the places and events that are important in her life: the temple she attends, the park where she met her husband, the Ryder near her house. Much of this map focused on her husband, how they met, how they support one another through challenges, and why she feels they are meant for each other. Her depiction of "sensory space" was not tied to a single room or setting, but a network of support that accompanies her wherever she goes.

She was deeply engaged in the workshop and told me she wanted to try collage as another way of expressing her ideas. The following week, she returned with a painting of a green grass, flower and blue sky, accompanied with poetry, the right most drawing in Figure 3-5. The lines she chose were reminders of self-care, self-worth, and resilience in the face harsh moments in life. Knowing that she has lived through the stress of moving from Nepal to the United States

and has survived a life-changing accident, it became clear how significant these transitions of life are to her. For Susan, memories of the joyful moment in life, and the support system that carried her through the difficulties, together form a safe space.

Susan's response to the prompt of describing an "ideal sensory space" was not what I initially expected, yet it illuminated something important. A sensory-friendly space, one that feels genuinely safe and relaxing, is built from accumulated experiences, meaningful relationships, and the presence of people we care about. These relational dimensions are just as vital as any material design. Beside developing tactile or interactive surfaces can support specific sensory needs, we also should aware the limit of technology and invested in resource that provide these emotional supports.

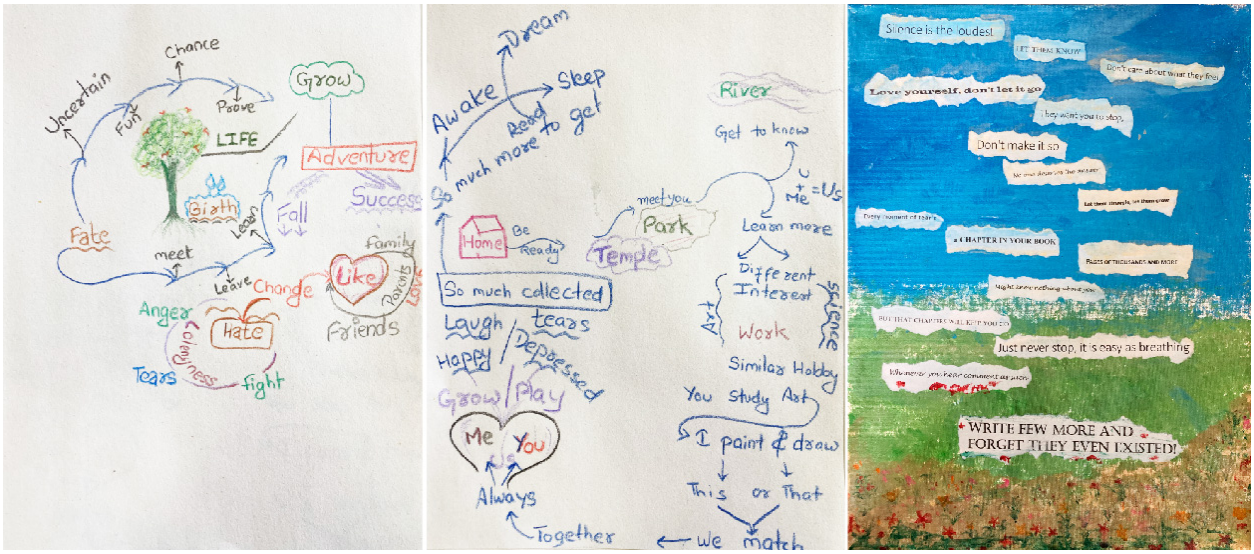


Figure 3-5: Susan's mind map of her life journey and the poem

While these activities offered space for creativity and personal expression, they also revealed access challenges that I had not fully anticipated. For example, inviting participants to create detailed representations of their ideal sensory spaces required a level of fine motor control that not everyone had. Mandy and Kelly both experience limited wrist and arm mobility. Mandy is painting a lot, her work often features geometric shapes and bold color blocks, holding a brush freely for expressive abstraction is easy to her. But sketching smaller details was more difficult. Kelly faced similar challenge, and she typically works with her caregiver, who helps her with the art-making.

When I introduced the workshop theme about picturing ideal sensory space, Mandy asked me whether she could print images of what she wanted to draw. Her question hit me, I suddenly realized how unthoughtful I had been in assuming that drawing by hand would be accessible to everyone. As we tried to sort out the printing process, Claire gently offered to write for Mandy, explaining that it was not a burden. She sat beside Mandy and collaboratively completed the mind map with her, Figure 3-6, while Kelly's caregiver did the same for Kelly. These moments reminded me that participatory work depends on interdependence rather than independence, and that collaboration is often what makes creativity possible. They also reinforced the importance of preparing extra time, mental capacity, and resources so I can remain flexible when unexpected needs arise.

These experiences made clear that accessibility is not a static checklist but an ongoing practice and leaning from each other. It is easy to miss come details and failed people in unexpected ways. Researchers must listen closely and adjust continuously to ensure that participatory research settings make everyone feel comfortable and supported in contributing their stories.



Figure 3-6: Claire help Mandy writing down the details of her mind map.

3.2 When Knits Blend into the Background

Even though knits are not necessary in the center of the sensory space participant presented in their artworks. Knits exist in the background. The boundaries of interaction were blurrier, participants would pick up a knit, fidget with it, then set it aside or continue using it while doing something else. For instance, at Disability Network, the classroom setting was open and spacious. People would arrive, browse the samples, pick up a few that caught their interest, and return to their seats. Some integrated the knits into their art-making processes; others used them more casually, fidgeting while chatting or waiting. In every workshop session, Susan would pick up anemone knits and bring it to her table, Figure 3-7, playing with it throughout the class. She didn't use these knits for her artwork; instead, she engaged with them on the side. Sometimes, she stacked them; other times, she flipped them inside out, exploring different forms of what they could possibly be, Figure 3-8. Similarly, during the wait time of our one-on-one interview, she arranged this knit connection into a landscape and speculated if the knit was bigger, it could be a lamp in her living room. When asked about the intention behind her creation, Susan said that she does not intend to make specific things; rather, she likes to have these soft objects at hand, playing with them to keep her mind off herself and prevent a fixation on thinking about her past or future.

> "It's like, if I'm having this material, it's not that I need to have it, but if I'm having it, I'll be, like, thinking about this and nothing else will be in my mind. So, in a way, I am. I will be watching, like, you know, movie or drama series, just to keep my mind off myself. Like, myself, my future, my past, nothing, that is the reason. Like, I joined art class. I joined some classes. I'm trying to engage myself with this thing. And if I'm having this one, it's like I'm having a phone with me and like, I'm thinking of, okay, what I can make, how I can make what I can turn this into and what it's going to be like. So, it's in a way, keeping me engaged. And also, like not breaking thing, not making them miserable."[4]

She shared with me that, after a severe car accident that forever changed her body, she has been sensitive to the idea of "breaking." She said seeing the permanency in change as reminders of her injuries. She said that soft materials make her feel safe because she can trust it

[4] Conversation during Lab visit in the University of Michigan, November 13, 2023.

won't break. She knows she can change the state of the material, but it is not permanent. If someone doesn't like it, they can change it back. Therefore, the soft and flexible knits became perfect objects for her to play with when she needed distractions. There's also an inherent agency in freeing everyone from seeing the artwork as fragile and untouchable, allowing for testing the boundaries of physical interaction and transformation of the malleable knitted pieces.





Figure 3-7: These are knit that Susan plays with in the first plaster casting section. In the material collage workshop, Susan, again, pick up anemone knit and play with in at the side.



Figure 3-8: Susan played with anemone knit while wait for her turn of the interview and fidgeting with them during the interview.

Susan never explicit stated she like the texture of anemone knit, yet anemone knit always show up in her background. In a similar case, Caroline's hold on to a knit designed that the stitches will drop when people stretching the knit. When she chatted with others, she pulls it apart slowly, stitch by stitch, as shown in Figure 3-9. What began as a casual gesture soon evolved into an idea: the deconstructed knit could become the hair for her mask. Later, inspired

by the color and texture, she chose a matching yarn and began crocheting a new piece, extending the original machine knitted form into something of her own creation.

These interactions, though quieter and more dispersed than those in the immersive installations, offered a different kind of insight. They revealed how tactile engagement doesn't always manifest as a distinct or performative act. Instead, it can operate in parallel with other forms of making, or emerge as a casual, everyday tool, a sensory resource that supports presence, focus, or simply comfort in a shared space.



Figure 3-9: Caroline playing with knits when chatting with the group and brainstorming on how to intergrade textile as the hair for the face cast.

At Ann Arbor Academy, the classroom space is relatively small, with students seated closely around a shared table, within arm's reach of one another. This proximity shaped the nature of interaction, the workshops became social spaces, where the act of making was intertwined with casual conversation. In each class, I would place bins of knitted samples at the center of the desk, inviting spontaneous engagement. Students would casually reach into the bin, selecting pieces to fidget with while chatting about friends, school, or recent trends. Often, one student's way of playing with a knit would catch on, prompting others to mimic or build upon it. The intimacy of the space also led to shared focus, moments when everyone leaned in to observe or comment on a single knit, Figure 3-10

Students' tactile preferences and interactions varied widely. Madison, for instance, enjoyed the subtle sensation of stitches unraveling beneath her fingertips as she pulled on loose threads, she would excitedly pull all the unravel knit into a tangled pile of yarn. Gina found satisfaction in patiently untangling that mess, Figure 3-11. Madison was also drawn to a sample that ripped open when stretched in a specific direction. She remarked that her ideal sensory space

would include materials that remain unchanged under one kind of touch but respond dramatically to another. She described this dynamic quality as a form of “passive texture”, something that appears inactive at first, but becomes activated through modes of activation, Figure 3-11.

Skyler, meanwhile, found satisfaction in repeatedly squishing the spacer fabric, holding it in her hands while chatting with the group, Figure 3-11. Mason was drawn to a piece of especially fluffy yarn, asking me to cut a section for her to take home, Figure 3-12. Though she is usually sensitive to touch, constantly wearing gloves, her interest in that particular material showed how specific textures could break through those sensitivities and offer comfort. Sometimes it’s not necessary about comfort, Knits has also been used in playful and expressive ways in Ann Arbor Academy. For example, Aspen wore them over their shoulders like fashion accessories, Figure 3-12, and Madison placed a knit on her crab plushy to make everyone laugh Figure 3-12.

These instances illustrate that even participant don’t see direct connection with these computational knits to express idea sensory space in their artwork, they still fidgeting with the knits alongside other activities, and everyone have unique preferences for the textures they engage with. From a material perspective, knits can serve as supportive objects, helping to ground emotions, keep hands engaged, and create a space where people can focus on conversation, creative practice, or simply being present. Placing these moments together indicates that seemingly small, tactile interactions can carry meaningful emotional and cognitive support, highlighting the importance of designing sensory spaces with attention to individual needs and experiences



Figure 3-10: Students gathered around a table exploring and interacting with knits at Ann Arbor Academy.



Figure 3-11: Students playing with knits.



Figure 3-12: Students playing with the knits and scrap material.

3.3 Futuristic Trash Diaper

Jasmine: I am making a trash diaper

Angela: oh, that's nice!

Jasmine: will you join me with my trash diaper? (making up and singing a song about trash diaper)

Jasmine: This is what you have to do when you go through menopause. (talking to Yi-Chin)

Yi-Chin: Really? Okay.

Angela: She is like, oh wow. (Pointed to Yi-Chin, laughing, assuming because i seems clueless in this menopause conversation)

Jasmine: As you get older, here we are

Claire: It looks like a very futuristic layer.

Angela: It could be a new look; you may be onto something.

Jasmine: Yeah, futuristic trash diaper![5]

There are many layers of conflict, negotiation, and discussion about care and bodily support behind the 'trash diaper' story. This is not about identifying what texture are preferred for a one's body, but rather a reflection on how a group of people navigates and negotiates their expectations of what constitutes a supportive public space, and what happens when those expectations clash. It adds additional layers to understanding sensory experience, showing that designing such spaces is not just about which textiles to apply to a surface; it also involves considering social boundaries between people, and the norm in the shared space.

Jasmine is a warm and generous woman. She greeted everyone when she arrived the space, she would initiate conversations and make sure no one feels left out. During the workshop, when she was in the mood, she is a steady and reassuring presence, offering food to share, affirming others' work, and helping create a welcoming atmosphere.

During the time the group shared their plaster casting experience, Jasmine shouted out at those who cast plaster on their hands or faces, saying that she found it daunting. She said that "I could never do that. You have to stay still for this, and I just can't." For Jasmine, it is impossible to stay still. Jasmine said that entering a new space is often overwhelming for her. She describes the feeling of uncertainty, not knowing where to go, or how to act. The idea of staying still terrified her.

The process of casting typically involves some part of the body staying still to allow the plaster to set. However, rather than letting the unease of "staying still" limit her, Jasmine thought casting her hip would be the solution. Jasmine said," I can't sit still, I don't like sitting, so I want to cast the body part that I can move or not move." Jasmine further explained, unlike casting a hand or face, this approach allowed her to move freely while waiting for the plaster mold to dry. She could shift, reposition, and keep her body in motion. The choice of casting her butt sparked a

[5] Conversation during plaster casting in Disability Network, October 2, 2023.

wider conversation in the group, not just about technique, but about comfort, privacy, and boundaries.

Jasmine stated she had no shame in showing her body in public. She said" I have work in the nursing home, I saw all kinds of bodies and all bodies are the same, nothing special, no need to hide." She added, "I'm not worried about my discretion." Her candid attitude, however, clashed with the norm in this group. Claire was concerned about maintaining a respectful environment for everyone. She suggested Jasmine use the family restroom for more privacy. Jasmine countered by asking if she could cast behind a movable wall, because she didn't want to isolate herself in the bathroom; she wanted to remain part of the group. But Claire insisted she cannot unclothe in the classroom in any circumstance. After a moment of tension of awkwardness, Claire suggested we wrap Jasmine up in the plastic wrap and cast on top of the plastic wrap.

It was our first workshop, the first time we had met, and there I was there applying wet plaster to Jasmine hip area and gently smoothing it with repeated pads. I had anticipated that body casting would be an intimate process with unavoidable physical contact, like holding someone's hand or touching their face to offer assistance. But I hadn't envisioned that the activity would involve navigating such personal terrain, touching someone's hip, discussing bodily boundaries, or talking about menopause. The experience pushed me to face the conflicts emerge when working directly with bodies.

During the time waiting for plaster to dry around Jasmine hip, she feels supportive, and comfortable. She said it just like sports bra for pelvis, like a diaper. She is saying that she is making "trash diaper", and joke around with Angela, Kelly's caregiver. Additionally, Jasmine expressed a desire for something soft against the skin, yet structurally supportive, an interior surface that offered comfort and an exterior resilient enough to bear her weight. She articulated a clear vision: a dual-materiality that could both soft and hard. She also proposed integrating eyelets into the cast design, allowing it to be tightened or loosened, invoking a sense of adjustability and autonomy in how the object interacted with her body

Disregard the other tension cause by the hip casting, Jasmine's put in lots of efforts to construct what she jokingly referred to as a "futuristic trash diaper", a support garment. Her engagement revealed not only her creativity and humor around body positivity, but also subtly

highlighted that bodily proximity, the closeness between bodies, materials, and space, is itself an important sensory factor in shaping a comfortable public space.



Figure 3-13: Jasmine holds her body in a slight curve to shape the hip cast the way she prefers.

3.4 Knits Inside a Pocket

Sensory support can come from people who care about us, a fidgeting tool that holds in the hand when chatting with a group, or an external structure that holds the body weight. For Felix it's objects or activities that shield their anxiety from reveled in front of others and make them feel in control.

The workshop at Disability Network began in October 2023, just as excitement for Halloween was building. During the first plaster casting session, many participants were eager to create masks or props for their costumes. As Halloween approached, conversations in the workshop turned to party plans and Halloween trip. Some participants went to the Halloween party hosted by Disability Network. When we returned to the art studio after the event, black and orange balloons were still hanging, making the space very festive. Susan joked about wanting to hang her spooky plaster mask outside her house as a Halloween decoration. Kelly shared her excitement about visiting the Halloween experience at Greenfield Village, describing the hayride, thousands of glowing jack-o'-lanterns lining the streets, the headless horseman, a haunted bridge, and even a towering pumpkin tree. Felix also joined in the conversation, saying that they had been working at a haunted house as an ambush-scare performer:

> Felix: So, the best is when people come in and they think something's happening on the bottom, very suspicious. And then the best is they look at the top one, decide there's nothing I have to worry about. And then I lie and wait. And then my time, my supervise

sent a signal then I wait, and I jump out and I have this scary mask on. and people love it, people will be like, oh you got me good, you got me good, good one!

Claire: I love that. Felix that's so perfect for you. I love that.

Felix: Yeah, and is a type of performance for not needing for myself, unlike my other ones, you got to just do it, you get paid to scare the crap out of people, with their consent. (Felix's other performance/artistic identity is a writer)

Claire: And it's the opposite of vulnerable. Right? Like you are in full power.

Felix: Yeah. Yeah. But there is consent. Like you're the scary one for once. (with a glowing face)

Claire: Yes, exactly. Yeah. [6]

When Felix shared that they enjoyed being a haunted house performer, they explained that the role didn't require them to reveal their true self, unlike their identity as a writer, where personal vulnerability often emerges through the work. In the haunted house, they simply followed a script and played a ghost who could jump out whenever and however they wanted. The role gave them a sense of power: they were the one who scared others, the one in control, within a space carefully structured by consent, as Felix thoughtfully emphasized.

Outside of the Halloween scenes, Felix moved through the room like breeze, their voice was soft and gentle, as if afraid of taking up too much space, very different with the haunted house performance-self they describe. One day after the workshop, they held a piece of knit in their hands, excitedly telling me how much they loved the material. It was a simple jersey knit, nothing more than a test piece I had made to evaluate the yarn I dyed. With no special design features, it was the most basic knitting structure, yet it had captivated them.

Felix was excited about the curling edge of the material, Figure 3-14. They said it reminded them of a blanket they had as a child, a blanket they used to uncurl at the edges while falling asleep. Felix called this thick, curly edge the "crunchy" part of the fabric. They also point out, especially the knit that made with monofilament, the curls are stiffer, less easy to uncurl,

[6] Conversation between Claire and Felix in Disability Network art studio, October 2, 2023.

make it even more “crunchy.” Felix described how repeatedly uncurling it brought them a deep sense of satisfaction and comfort, their face reflecting that same delight as they spoke. Felix said they can just hold this knit in their pocket and touch it all day.

This was a striking moment for me. Among all the intricate knits I designed to showcase the possibilities of precise machine control, it was the simplest one, a knit made merely for color testing, that Felix loved the most. In textile design, curly edge often delivers the image of crafty, not sharp, and unfinished. Designers often want to eliminate the curl through trimming, tensioning, or changing the knit structure at the edge of the knit to prevent it happens, like the ribs knit at the end of the knitted sweater. What I saw as an unintentional byproduct of the knitting, Felix saw as a source of joy.

Felix got overwhelmed easily at certain environment, sensitive to the way spaces hum and vibrate around them. There were moments when the noise of ventilation became too much, and Felix would quietly retreat to a corner, putting on ear plug, withdrawing from the group. One afternoon, the noise seemed especially agitating. Just as they were trying to self-regulate, I approach to ask them to choose which gift card they want as compensation for their time spent in the workshop, Joann, Michael’s or Blick. Felix opened the websites of the craft stores to see what each offered. But the saturated colors, dense visual stimuli, and endless scrolling of products created a kind of sensory and information overload. The number of options only added to the stress, leaving them paralyzed by indecision. In those moments, Felix either needed to wear earplugs or step away entirely. To cope, they instinctively reached for something small and familiar, a soft piece of fabric, just the right size to fit in their palm. Holding it, repeatedly unfold the curling edge between their fingers, secretly gave them a sense of grounding, a small anchor in a sea of overwhelming sensations. In this way, no one needed to know they were overstimulated, just as, in the haunted house, they could place a scary ghost in the scene without revealing the parts of themselves they preferred to keep private.



Figure 3-14: Felix holding two knits they love the most.

When juxtaposing Felix and Jasmine's preferred forms of sensory support, a clear contrast emerges. Felix gravitated toward a small, fidget-friendly knit he could tuck into their pocket, something discreet, offering a sense of ease when anxiety arose. Jasmine, by contrast, expressed a desire for a sturdy, supportive external structure, one that could also function as a bold statement of body positivity. Despite these differences, both narratives reveal a shared need for tactile intimacy and portability in sensory engagement: Felix sought something curly and pocket-sized, while Jasmine envisioned soft, fluffy yarn as the inner layer of her 'trash diaper,' that will support her wherever she goes. In both cases, the objects transported them into different emotional times and spaces, the curly knit reminding Felix of a childhood blanket, and the trash diaper representing the futuristic garment Jasmine imagined would support her body and ease her spatial anxiety

Whether or not people imagined their sensory space involving knitted textures, their descriptions all pointed toward a supportive environment, and support takes different forms for different people and in various contexts. It is impossible to design a single tool or space that magically fits everyone's needs. However, by observing how participants used the knits and listening to how they described the qualities of a sensory-supportive tool, these stories highlight specific design strategies that may be useful when arranging community-engagement activities or designing sensory-supportive knits. One important strategy that consistently emerged is the consideration of scale and portability.

3.5 Precision at Intimate Scale

The conclusion of this chapter is that the size and scale of the knits play a crucial role, not only in terms of functionality, but also in shaping the forms of participant engagement, the kinds of interaction that emerge, and the types of knowledge that can be generated. Working at a small scale may sometimes limit the perceived relevance of the work to traditional architectural contexts, yet it also offers unique opportunities for intimate tactile interaction, more control for participants.

In architecture and computational design discourse, scaling up is often treated as a proxy for success, particularly in immersive or experiential environments where greater coverage, intensity, or technological complexity is assumed to produce richer engagement. This logic can be observed in successful public installation work (Sabin 2018; Sabin et al. 2020), where size and visual spectacle function invite broad engagement. However, my fieldwork with neurodivergent participants demonstrates that a larger scale does not necessarily enhance immersive tactile experience. While large installations can serve as social focal points or conversation starters, many participants engage most meaningfully through intimate and repetitive interactions at their own pace. Moreover, smaller pieces that can hide in a pocket or under the table also reduce social visibility, which is particularly important for disabled and neurodivergent individuals who may otherwise feel pressure to mask or regulate their behavior in public contexts.

Machine knitting is particularly well-suited to working at small scales while still sustaining a high resolution of material differentiation and tactile control. Knitted textiles occupy a unique position in the material world: their tactile qualities emerge from a hierarchy of design parameters ranging from fiber type (wool, cotton or synthetic), yarn twist (Z- or S-twist), ply, stitch type (knit or purl), stitch pattern (rib or spacer), and overall shaping (sheets, tubes or pockets). Each parameter, from the smallest fiber details to the design form, affects both tactile experience and functionality of knitted material. Computational control over these parameters allows rich variation and precise tactile combinations to meet particular sensory needs.

For example, Felix enjoys flipping the edge of knits in their pocket to ground themselves when overstimulated, yet not every knit works for them. They preferred pieces with monofilament edges, which retract quickly and sharply when uncurling, creating a “crispy” sensation distinct from polyester curls, as Felix describes. Achieving this effect depended on

precise machine control, stitch length, machine tension, and material choice, all of which contributed to the structure. If settings or material selection were slightly off, the tactile response may not feel the same.

This example highlights how, in computational knitting, precision in yarn preparation, manufacturing processes, and machine control can profoundly shape sensory experience, even when such differences are imperceptible at the architectural scale. Rather than framing precision and control as inherently problematic or against lived experience, this work demonstrates that precision operates differently across scales, contexts, and purposes. Attending to these differences' positions control in computational design as a site of negotiation when human subjects are involved, rather than as an assumed or uniformly desirable goal to pursue.

Thinking about scale in participatory design also draws attention to resources, accessibility, and affordability. During early conversations with William Purves, the director of accessibility and education at Disability Network, he noted that the facility could not accommodate large-scale installations. Physical space is often a scarce resource in non-profit contexts, something researchers coming from well-resourced university labs may overlook. In contrast to architectural student projects, which are often displayed temporarily and assembled in a controlled space that is dedicated for exhibition, working with local communities involves different timelines, constraints, and resource limitations, highlighting the need to carefully discuss the design scale and commitment with community partners, rather than treating scale as a purely design-driven decision.

This chapter concludes that smaller knitted artifacts are portable and flexible in the mode of interaction, enabling intimate and longer engagements that are particularly valuable for understanding how supportive sensory spaces are formed in everyday scenarios. The capacity of knitted materials for personalization also engages questions of design agency, adaptability, and participants' ability to actively shape their environments. The next chapter examines these topics further, focusing on the tensions that arise when the knits are cut.

Chapter 4 “Please Don’t Cut the Knits”: Negotiating Design Agency Between Machine Knitted Material and Scarps

The chapter argues that when knitted artifacts are presented as perfect, flawless, and complete, they can unintentionally communicate a subtle message that the work is already resolved and not open to engagement. The knits I brought into the community were often perceived as artworks, “Yi-Chin’s creations,” which made participants hesitant to reshape or alter them. This dynamic, in turn, diminished their sense of agency when working with knits that were meant to invite collaboration.

The chapter begins with a story that reveal how participants rejected the polished aesthetic of machine-made knits. Many preferred to work with scrap materials, where they felt less constrained, and re-create without fear of “ruining” something. Following, I reflect on a tension that arose when participants wanted to cut the knits, and I found myself intervening to prevent alteration, out of my instinct as a crafter, as well as my ego and sense of design authorship.

Next, I document an interesting comparison on how different groups responded to this perceived “perfect knit. “Adults in the disability network approached the knits with greater caution, whereas teenagers at Ann Arbor Academy engaged with fewer reservations, cutting, altering, and improvising with the material without hesitation.

The chapter concludes by drawing together these tensions and considering how computational design practices might better support shared authorship rather than produce polished, finished objects. I argue for designing materials that remain flexible, open-ended, and welcome messiness, inviting touch, modification, and co-creation to foster meaningful community engagement practices.

4.1 Not My Aesthetic

Kelly is a participant in Disability Network who has a movement disorder. She often moves slowly and always enters the space with a caregiver. During the plaster casting workshop,

Kelly cast her arm in a twisted pose to represent her dystonia, characterized by involuntary muscle spasms that move her arm into twisted and uncomfortable postures. Kelly shared that the symptom started when she was thirteen, and then it progressively got worse to a point where she was incapacitated on the couch. During the casting process, she said that when the plaster dried on her skin and gradually limits her motion, it also feels like a muscle spasm episode, Figure 4-1.

Once the plaster cast was complete, Kelly selected a knit with a pink and blue stripy pattern and wrapped it around the forearm of the cast. Over the knit layer, she added a multicolored blend of scrap yarns, winding it around the arm and the wrist, Figure 4-3. Kelly explained that her movement disorder makes her life full of uncertainty since she never knows when the muscle spasm will happen, and when that happens, her body move involuntarily and become momentary stuck. These spasms can tighten her mouth, twist her arms, and even make breathing difficult. For her, the stripy pattern produced by machine represents "order" in moment when her body is in control, while the tangled yarns symbolized the uncertainties brought by her disability. Her interpretation of the contrast between machine-knitted structure and scrap yarn was striking; the orderly, linear pattern simply did not resonate with her lived experience.

In the final workshop, I brought each participant a customized knit inspired by their previous artworks or comments as a way to check whether my interpretation aligned with their intentions. For Kelly, I created an arm sleeve, Figure 4-5, incorporating multiple unraveled sections that using the spacer-fabric technique. This structure allows people to unravel the top knitted layer (the pink yarn) to reveal the middle layer without compromising the overall knit structure. In that middle layer, I throw in a pattern generated with noise algorithm to add irregular patterns that disrupted the knit's linearity.

Kelly was delighted with the piece. She pointed to the bumpy surface areas and said she loved how the surface is "not all straight," "just like the bumpy things in life."



Figure 4-1: Kelly's plaster arm, casting while she intentionally twisted her arm to mimic the muscle spasm.



Figure 4-2: Krista rolling the plaster cast with a strippy knit.



Figure 4-3: Kelly’s plaster cast with decorative elements, including lose yarns, machein knitted material and scrap fabrics.



Figure 4-4: Prototyep of kelly’s unravered sleeves.



Figure 4-5: Kelly and the knitted unraveling sleeves

4.2 “May I Cut the Knit?”

From the very beginning of my knitting journey, the idea that “every knit is a continuous thread” has been etched into my mind. This fundamental difference in fiber structure between knitted and woven fabrics deeply influences how I manipulated the yarns and fabrics.

Woven fabrics are made by interlacing two sets of yarns: the warp, vertical, continuous, and typically under tension, and the weft, horizontal yarns that may or may not be continuous Figure 4-6. If a weave was cut, the edges may fray, but the overall structure remains stable.

Knitted fabrics, on the other hand, are formed from a single continuous yarn that loops through itself to structure the fabric. Cutting a knit can lead to a cascade of unraveling, as the looped structure depends on every loop holding the next in place. Because of this, I’m always anxious whenever I see sharp objects near a knitted piece, one accidental cut, and the whole fabric could start to run.

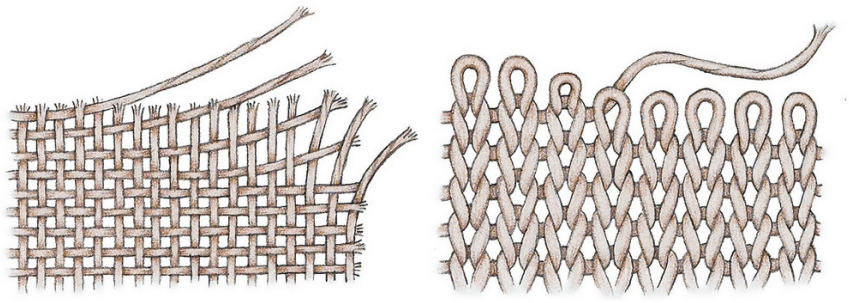


Figure 4-6: Left: woven structure; right: knitted structure. Images source: https://threadden.com/sewing-tips/the-difference-between-knits-wovens/

https://threadden.com/sewing-tips/the-difference-between-knits-wovens/

When I brought machine-knitted pieces into the art-making workshops, many participants asked whether they could cut the knits into shapes that better fit their artwork, whether to decorate a plaster cast or incorporate them into a collage. These requests immediately activated my “unraveling alarm,” and I found myself reflexively saying “no.”

One moment that made this tension especially visible occurred when Susan was decorating her plaster mask. She wanted the mask to resemble herself. After her accident, she explained, she rarely dressed up or wore full makeup, and she hoped to “dress up” the mask and give it to her husband as a gift. Susan has long black hair, and she wanted her mask to have it

too. She asked if she could cut the black section of a knit, Figure 4-7, to fit the contours of the mask.

After I politely declined, she turned instead to the scrap materials and began inventing her own solutions. She used small black felt circles to create a full head of hair, added yellow yarn as earrings, and even crocheted a small garment specifically for her mask, Figure 4-8.



Figure 4-7: that Susan collected on her desk to play with



Figure 4-8: Susan's plaster mask with decorations.

In the other research site, the dynamic at Ann Arbor Academy revealed a very different relationship to the "rules" of working with knits. Aspen was experimenting with one of the pieces designed to be unraveled. She played with the fluffy surface left behind after unraveling and quickly discovered that because the pink yarn remained connected to the bottom layer, pulling on it at different points allowed her to subtly reshape the knit. I was impressed by how quickly she grasped the material behavior. But only a few seconds later, when I turned my head back to check on her, Aspen had already taken a different creative leap: she simply cut the knit in half and combined the two pieces with other knits. She proudly shared with the group that she had made a bow and arrow from the cut and recombined knits, Figure 4-10. The knit was cut, nothing unraveled catastrophically, and what emerged instead was creative, improvisational play.

In running the workshops, I usually tried to be flexible and responsive to participants' needs. For example, when students at Ann Arbor Academy did not feel like making a collage, I offered alternative art-making tools. On rainy days, when someone felt low and didn't want to create, I never pressured them to produce art for the sake of research; they were always welcome to simply relax and chat with the group. However, my flexibility was gone when it came to

cutting the knits. I drew a hard line and rejected these requests without hesitation, driven by the fear of watching carefully looped threads unravel into something I cannot control.

I don't want participants to cut the knit, not because I cherish my design and don't want to share it. In fact, I wanted them to use the knits freely, to build artworks that expressed their ideal sensory space. But the idea of cutting the knit scares me. It triggered a fear that, once cut, the knit would no longer be a "knit," just a pile of tangled yarn. Therefore, I suggest they use the scrap woven or felt if they want to cut something into the shape. I worried that if participants cut them, the knits would fall apart, and I would lose the ability to trace their choices back to those qualities. In hindsight, I see how silly it was.

Reflecting on these moments, my insistence on maintaining integrity and the idea of "knit "sabotaged my own research. Aspen's bow and arrow reminded me of the kind of creative use of knits I had hoped to see and made me realize how many opportunities I missed by not allowing participants to cut the material. Similarly, Susan's self-made crochet garment makes me reflect on how the knits I made already carried specific styles, colors, and intended functions, which may not always align with participants' intentions. Creating material from scratch or assembling pieces from scraps, in contrast, gives people greater control to realize their design, and it brings joy and a sense of achievement, just like I enjoyed producing knits for my research.

The following section turns to a deeper examination of how "destruction" and material exploration without strict boundaries can foster positive experiences, support creativity, and function as a form of sensory-supportive space.



Figure 4-9: Aspen pulling threads from the fabric to explore how the material changes shape.

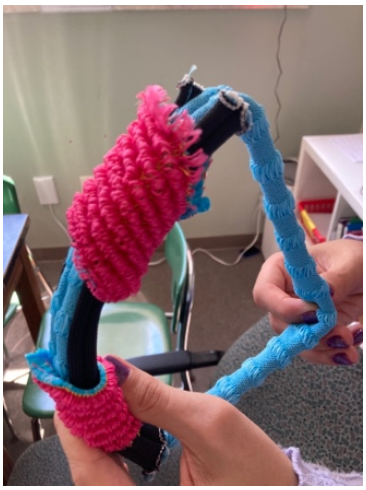


Figure 4-10: Aspen cutting spacer fabric and collecting other knits to assemble a bow.

4.3 Destruction as a Sensory Experience

While my initial hesitation around cutting and altering knits revealed my own attachment to material "integrity," the workshops also showed that unravelling, deconstructing, and reshaping materials can be a profoundly creative and positive process. Far from being destructive in a negative sense, these acts of dismantling allowed participants to explore freely, assert agency, and enjoy the rebellious moment. This section examines how material "destruction" can open new possibilities for creative play, sensory engagement, and collaborative art-making.

On a relax Thursday afternoon, only Madison and Aspen came to the final workshop; they were raiding all the unraveller in the knit bucket and determined to unravel them all. They start by doing the unraveling separately and then joining the force, wanting to speed up the unraveling process. Aspen was holding the knit, standing by the door, and Madison kept pulling and winding the knit to her palm, Figure 4-11. At some point, Madison's palm was not enough to hold all the unraveled yarn, so she transferred the yarn onto a chair, as shown in Figure 4-12.

Destruction emerged as a form of play when I introduced the unraveling knit to the group. The destruction here did not mean the violent breaking without purpose; it points to the actions that undo or disassemble the given to further explore with curiosity. Besides enjoying the sensory click stemming from the unraveling process, students see pulling yarn out of a knitted object and see it turn into a messy pile as a rebellious act. There is a pleasure in conducting the act of "tearing it down." On the contrary, students in AAA are aggressively unraveling all yarns, adults in Disability Network only unravel a little bit to feel the clicky-feeling of unraveling and place it back for other people to try.

There were many moments of "destruction" that afternoon that I did not se coming. It began with the students aggressively unraveling yarn well beyond the gentle, calming "sensory stimulation" I had imagined. Soon, student bring the big pile of loose yarn and running out of the classroom to visit friends in neighboring rooms, which immediately triggered my internal "disobedience alarm." When they began tossing yarn balls across the hallway, I became anxious, worried they were "breaking the rules" and unsure how I was supposed to intervene. Meanwhile, Aspen pulled on parts of the knit that were never designed to unravel and eventually cut the material entirely for her material exploration.

Although I was glad the students were having fun, it took me a long time to understand what their reactions meant, and how these moments connected back to my research questions about designing sensory-supportive spaces. In retrospect, these actions, cutting, pulling, unravelling, reshaping, were not simply chaotic or "misbehaving." They were expressions of agency. Destruction or undoing can be an intense and direct way to claim control over a material, especially in contexts where agency is often limited or discouraged.

When the knits were designed to invite unravelling, they became outlets for this kind of rebellious engagement. And being rebellious, having permission to undo, dismantle, and remake, can itself generate positive feelings of autonomy and play. In this sense, material "destruction" became a form of sensory support, offering comfort through control, exploration, and the freedom to act without constraint.

The next section turns to another form of sensory space, one that is both conceptual and deeply material: textile exploration and re-imagination. I present a series of participants' material experiments, with and without knits, to illustrate how they manipulated, transformed, and reinterpreted the materials around them. Through these examples, I return to the central argument of the chapter: how computational design practices can either support or constrain participants' agency within participatory research.



Figure 4-11: Aspen and Madison playing with unravellers.

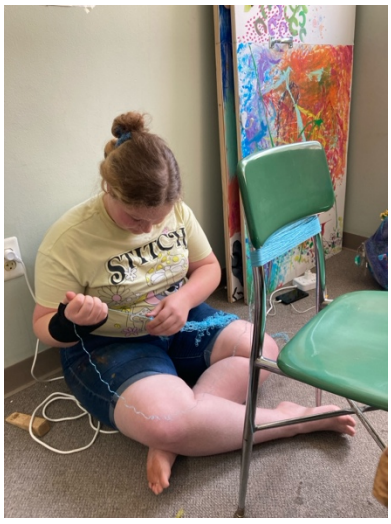


Figure 4-12: Madison winding unraveled yarn around a chair.



Figure 4-13: Students throwing yarn balls to one another.

4.4 "I am Not Really Interested in Textile"

In Chapter 2, some participants clearly identified specific knits they enjoyed fidgeting with. In this chapter, however, we see many instances where participants were less concerned with the knits. Such as Kelly stated the aesthetics of machine-knitted pieces is not for her, Susan wanted to cut open the knits for the color purpose, and students at Ann Arbor Academy seemed to enjoy the process of unraveling the knit then the knit itself. Cutting or dismantling a knit does not necessarily indicate they don't enjoy the knit, participants were do it to explore or repurpose the material, but there were also moments when participants explicitly stated that textiles are just not their jam.

Mandy is a disabled artist with a distinct art style that painting with strong line drawing and vivid color blocks, Figure 4-14. In the collage section, she created a collage that mix with yarns, woven fabric, knitting samples, and felt. I was excited to see she picked up some knits to place in her work, however, when I asked the reasons behind selected those knits. Mandy explained that she is not particularly interested in textile, and she chose them simply because they look different from one another.

She explained that the collage serves as the backdrop for her plaster cast, creating the impression that the hand is actively drawing the surrounding textures, as shown in

Figure 4-16. The yarn she glued to the canvas references the signature intersecting linework in her painting practice. She included woven fabric, knits, and felts to reflect the multi-material and multi-color nature of her artistic work, in this context, the fabrics function more symbolically than sensorially.

In addition to the materials arranged on the canvas, Mandy decorated the plaster cast itself by winding strands of colorful yarn around the wrist. Compared with Kelly's more spontaneous decoration, Mandy's wrapping appears tidy and curated, echoing the coloring logic of her artwork.

Mandy explained that the plaster had been cast while she was holding a pen, a choice meant to document her distinctive way of gripping painting brushes. Due to limited flexibility in her hand and wrist, she holds a pen using all her fingers, guiding its movement primarily through her wrist rather than fingers. This adaptation shapes the unique stroke quality evident in her drawings. She described this practice as a form of "creative accommodation," a technique developed for daily life that has become an essential part of her artistic signature.

The yarn wrapped around her wrist also carries personal meaning. Mandy noted that it represents the heavy medical brace she wore in childhood. Although she no longer remembers the exact medical reason for the brace, the sensation of its weight remains vivid. Here, the yarn operates as a material trace of a passed bodily experience, it less about an expression of her tactile preference.

For Mandy, texture preferences are deeply tied to specific activities and contexts, such as the grippy pattern on her horseback-riding pants or the brace she once wore. She does not relate to textures in isolation; their significance emerges through the situations in which she first encountered them. Without those lived experiences, she explained, many textiles hold little meaning for her.

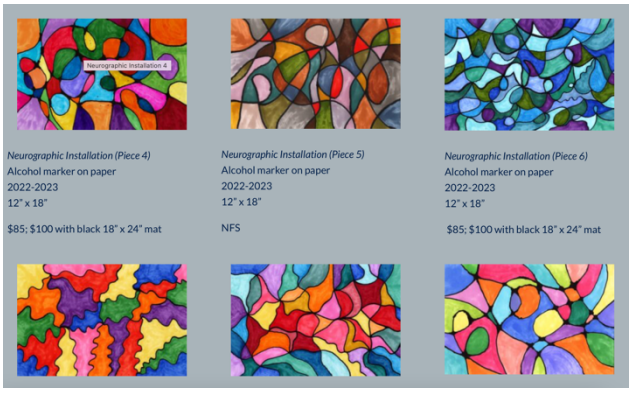


Figure 4-14: Mandy's artwork, which feature strong and organic lines divided colorful blocks. Image source: https://dnwml.org/colorlineexhibit/



Figure 4-15: Mandy collecting scrap materials for her collage.

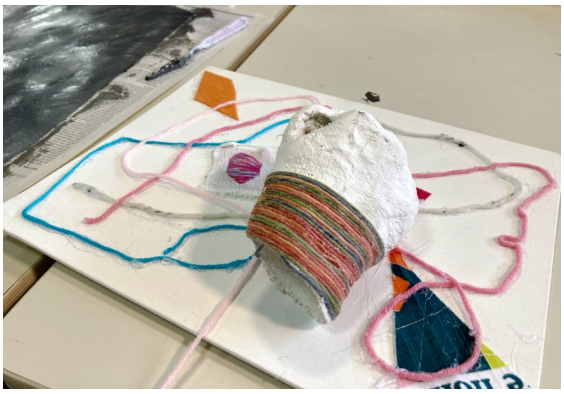


Figure 4-16: Mandy's collage with her plaster cast as the center piece.

Mandy's example highlights how textures make meaning through lived experience rather than through their material properties alone. This relationship between memory, activity, and sensation also surfaced, though in a very different way, in the work of another participant, Tim.

Tim, another member of the Disability Network, on the contrary, expressed a strong interest in working with textiles, was particularly drawn to materials with coarse, highly tactile surfaces. However, rather than engaging with the knitted samples, he gravitated toward an assortment of scrap materials that allowed him to pursue his own design interests.

During a plaster casting session, Tim proposed a creative casting approach: incorporating fabric scraps into the process. He envisioned layering fabric on the face before applying plaster strips, allowing the fabric to mold into the mask and create a softer, more comfortable interior. As he excitedly described his idea, he delved into every possible step, eager to refine his method. However, Claire, the program director, raised concerns. would the fabric hold its shape as he intended? Could the weight of the material pose a risk of suffocation during casting? Despite these challenges, Tim remained persistent, passionately advocating for his idea until Claire ultimately put a stop to the discussion. Tim's enthusiasm for material experimentation is evident.

Tim was consistently drawn to coarse textures, and many of his artworks centered on materials with this tactile quality. When decorating his plaster cast, he chose transparent mesh tubing, wrapping it around the contours of his hand to create a defined outline. I asked whether his choice reflected a preference for the mesh's rough texture. Tim explained she pick that mesh tube up because he like the transparent and airy appearance. and that remind him Michael Jackson's iconic glove, so he decorates the glove as an homage to one of his favorite artists. In this context, the mesh was less about its tactile properties and more about its Tim's visual

memory toward the popular culture he loved. This interplay between texture, meaning, and creative inspiration became even more evident in the next workshop session focused on constructing narratives of an ideal sensory space.

In this workshop, Tim shifted to a new line of experimentation. He selected a few pieces of white fabrics and used a hot glue gun to squeeze out lines of glue, constructing a tactile landscape that included a house, trees, the sun, and clouds on the fabric, Figure 4-19. As the glue cooled down, it bonded to the fabric and solidified into ridged forms, allowing him to "draw" not only with shape but with texture. He spent considerable time refining techniques for producing grooved, elevated textures with the glue gun. Tim explained that his inspiration is coming from the Bird's Nest, the National Stadium in Beijing. He to recreate a texture drawing that mimic the interwoven steel beams and semi-transparent façade.

Observing him work, I could sense his enthusiasm for experimentation, his impulse to push materials beyond their conventional purposes and see what new forms they can bring. These explorations clearly brought him joy and a sense of accomplishment. At the same time, it became increasingly evident that the knitted samples I provided were not flexible or versatile enough to support the kinds of structural and textural investigations he was pursuing. Furthermore, the visual references he invoked, Michael Jackson's sequined glove and the Bird's Nest stadium, further illustrate that, for Tim, texture is never just about physical sensation. Rather, it is intertwined with pop-cultural imagery, personal associations, and the everyday references that animate his imagination.

Mandy and Tim's works illustrate a mode of engagement driven less by my research prompt or the knitted materials themselves, and more by the open-ended opportunity to play, improvise, and explore. For both participants, the knits functioned simply as one option among many rather than a focal point. Their tactile preferences did not map tightly onto the knitted structures I designed, nor did they seem motivated to articulate any connections. Instead, their creative choices revealed a desire for experimentation and self-expression.



Figure 4-17: The glove worn by Jackson during the 1983 ‘Motown 25’ TV special. Image source: https://www.independent.co.uk/arts-entertainment/music/features/michael-jackson-s-one-white-glove-rhodri-marsden-s-interesting-objects-no-105-a6934371.html



Figure 4-18: Tim’s plaster cast with a transparent mesh tube decorating the edge.



Figure 4-19: Tim’s diorama and hot-glue drawings on the fabric.

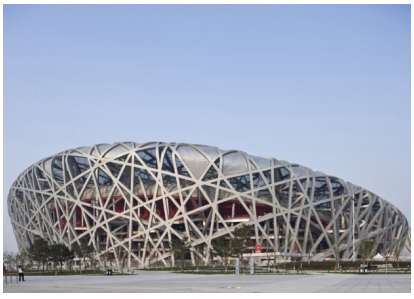


Figure 4-20: Tim’s inspiration artwork inspiration - Herzog and de Meuron’s ‘bird’s nest’ National Stadium in Beijing. Image source: https://www.architectsjournal.co.uk/archive/beijing-birds-nest-stadium-wins-coveted-lubetkin-prize

4.5 How Can Computational Design Support Material Exploration

This chapter illustrates how machine-knit material, along with me as a facilitator, was intended to support participants in imagining and shaping their sensory spaces yet introduced unforeseen barriers instead. By observing how participants navigated, manipulated, or disengaged from these knitted materials and the limitations I imposed, this chapter aims to highlight the creativity of participants making things work for themselves and enjoying playful material exploration. Furthermore, the chapter highlights the limits of "designed-for" sensory experiences, especially when the material arrives pre-designed by the designer's assumptions, preferences, and logics, even though they aim to be open-ended.

These moments of mismatch suggest that computational design enables certain aesthetics, forms of creativity, and modes of interaction while rendering others less legible or less possible (Deamer 2015; Bardzell et al. 2016; Bean and Rosner 2014; Rosner and Ames 2014). They also raise the question of whether some forms of sensory engagement and material exploration simply exceed what a computational design process can support. Rather than positioning computational design in opposition to sensory play or material exploration, these fieldwork experience suggests that the two are not mutually exclusive, but that current computational frameworks rarely make room for the design that is hard to describe by quantifiable parameters. The kinds of curiosity, improvisation, and rule-making that computational designers experience in their own design processes are not always transferred to, or accessible for, the people who ultimately meet these designed objects.

In a research lab, play and exploration for computational designers often mean experimenting with new technologies, probing the boundaries of machines' capacity, or discovering how materials behave under certain constraints. During the field work, I observed how participants manipulate material to make work that communicates sensory space. They also sought to understand the underlying logic of material behavior and used these discoveries to create something of their own.

For example, Tim discovered that hot glue could bond to fabric and cool quickly enough for him to draw scenery directly with it. Aspen pulled both ends of a spacer fabric and found that when pulled along the weft direction, the yarns were mobile, whereas pulling along the warp direction, the yarns interlocked in place. Based on this insight, she cut through the weft direction,

so the fabric won't fully break apart. Similarly, Susan's mind maps may appear random at first glance, but they follow a clear internal logic: each map begins with her home and gradually expands outward to explore a larger world. Their creative exploration and expression are analog but are not random; rather, they reveal the possibility for a more hands-on, improvisational, and open-ended design process.

Researchers working with digital technology raised the concern about the design process overly emphasizing the power of computing and encouraging people to explore alternative ways of making and communicating computational making. Sengers et al. proposed design strategies to reflect on unconscious values embedded in computing and the practices that it supports, urging researchers to examine the dominant metaphors and values, whether they are mismatched with users. Devendorf asks what it would be like if the computer and the human exchanged spots in the digital making process? How can we learn from being or thinking like a machine and taking commands from other humans(Devendorf and Ryokai 2015).

Researchers in architecture also ask, how can computational design support the crafting process that is very hands-on, situated, and rooted in a culture that cannot be fully represented by digital technology (Noel 2017). Cultural theorist Manning used the concept of minor gesture to explore variation, transform relation, and challenge dominant norms. Manning explains that Major is the structural tendency that organizes itself according to predefined values. The minor is a force that courses through it, softening its structural integrity, problematizing its normative standards. Minor gestures are not planned; they emerge and respond to the situation; they connect events and make meaning at the moment and then move on. Therefore, Minor gestures are pragmatic, speculative, and everywhere (Manning 2016).

While computation design can read as major gesture, it can be morph with minor key from within. Participants' creative acts and their accommodations to the knits can be understood as minor gestures. Their creation or reaction to the material only makes sense in the moment and in a specific context; many cannot be repeated and cannot be translated into generalized application or solutions. This highlights a tension between the generative logic of computational design and the dynamic, improvisational gestures outside of research labs.

Computational design's strongest suit is generating variations to support adaptation across different scenarios and customization needs. At the same time, computational design also embodies a particular aesthetic and style of making, which is driven by algorithm, that does not

necessarily align with the people outside the field, who usually related to objects through memory, popular culture, or personal interests. During the workshop, when machine-knitted artifacts did not align with participants' needs, they each developed their own ways of adapting the materials, most commonly through cutting, gluing and reassembling. This observation raises an important question for participatory research in the context of computational design: how might computational design support a similar degree of freedom, enabling participants to meaningfully alter and appropriate designs rather than merely customize through predefined parameters?

Building on the theme of supporting participants' agency in design, the next chapter documents moments when the plans, rules, or logics embedded in the computational design workflow did not align with the community partner's agenda. Through examining these points of conflict, Chapter Four more broadly discusses how computational design workflows can accommodate uncertainty during participatory research.

Chapter 5 Magic Doors: When Things Go Off-Course

This chapter documents the Magic Door project initiated by students at Ann Arbor Academy. The project revealed how students continuously renegotiated what a "magic door" meant each week, and how the collective effort ultimately resulted in a series of individual drawing pieces that talk about different stories. The door installation remained in place for several months before being taken down because the school is expanding and needs to repurpose the common space.

5.1 Magic Door

It was Michigan mid-March, a gray and rainy day. Thunder rumbled outside, and the crummy weather seep into the classroom. The groups energy is low; students are decorating their plaster body casted last week. Brook, who usually the leader of the group said she feels down, don't want to do anything, just want to sit on the floor. Madison broke the quiet atmosphere, asking for music, insisting they didn't like the silence.

With warm, peaceful, and occasionally sad Studio Ghibli music playing in the background, I began a conversation to wrap up the plaster casting workshop and check in on the group's status to move forward into the next project, the narrative of sensory space. As usual, Madison and Brook were active to sharing their thoughts, Aspen chimed in with her characteristic sass, and Audrey, as usual, answered "no" to every question I asked.

Since the students were still excited about casting and reluctant to move on. I posed a question: "What part of the casting process did you enjoy the most?" Student mostly excited about the messy process that they play with a new medium, they can decide how to craft it, and most important of all, don't need to sit down. some people started to debate on the whether they feel hotter or colder when the plaster drying on their skin. The discussion unlike the discussion in Disability Network that people linked the experience to their disability restriction or the fear of getting stuck. I further asked, if you can apply plaster on anything you want, what would you like to cast? in my mind, through this question, I can start to probe what kind of surface texture

they are interested to cast, to replicate, and from there many there are some insight to inform the sensory preference I am looking for. Brook said, “an egg”.

I was surprised and not sure what to respond. I asked: “Why?” Brook said, “I just want to see how the plaster reacts to the egg.” Apparently, casting to me is a method to capture the form and surface texture, yet for them, it’s just a new medium they can play with. However, I am not satisfied with this answer, I kept pushing further: “I mean, if you can cast on 'anything', maybe an elephant?” I was trying to encourage the student to think of something with more texture. Students responded to my question with laughter. Brook said,” There is no way you could do plaster on an elephant! “

As I was return to the egg proposal and explaining the difficulties of casting an egg, how it would be hard to remove the egg once covered it in plaster, Brook suddenly asked, “Can we cast a door?” Audrey immediately lit up and, in contrast to her usual refusals, began enthusiastically seconded Brook’s idea. And then the conversation moves on to casting the door handle, as Madison and Aspen suggest that’s the object we touch every day. The door topic liger in the group, and the magic door project was borne.

Madison: Door, or like, just a wall, maybe a little secret door

Brook: Oh, that would be nice, can we put paints on the wall and then have that door handle hot glue to the wall?

Everyone: yes!!!

Aspen: (Pointed to the wall in the classroom) This wall is looking really empty, so

Natalie: We can put a secret door handle on this wall, yeah!

Brook: The door of imagination or the door to map, a door to something fun. [7]

In my original plan, I had intended to introduce collage and mind mapping as ways for students to narrate their imagined sensory spaces. I prepared prompts such as: Where is this sensory space located? Who is there? What are people do in that space? These activities were

[7] Conversation in Ann Arbor Academy, March 14, 2024.

meant to courage students visualize and describe their idea sensory space with more details with creative medium. However, when the idea of the Magic Door emerged, accompanied by the students' ongoing excitement with plaster casting, I decided to shift course. I attempt to use magic door as a medium to continue collect the data about their sensory preference.

As the result, the next stage of the workshop centered on building a door that could open into an imagined sensory world. The tasks for students were designing the door and imagine what might happen behind it. For those still drawn to plaster casting, I suggested they find everyday objects or textures that felt connected to the Magic Door and make plaster casts of them, and we can incorporate those plaster casts onto the door itself.

This collective magic door distinguished the workshop from the earlier sessions I had conducted at the Disability Network, where the artwork was individual. Both Natalie and I were excited by this new direction. Natalie thought it would be a valuable opportunity for students to engage in a collaborative project and to produce something that could remain at the school as a creative installation. Figure 5-1 and Figure 5-2 show my initial sketch and 3D model of the Magic Door, which Natalie use it to pitch to the school board member to receive approval for installation.



Figure 5-1: My initial sketches of the magic door

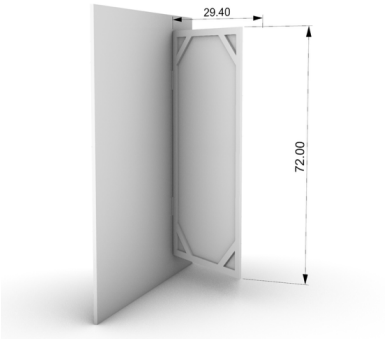


Figure 5-2: The proposed dimensions of the magic door

5.2 Every Class Is a New Start

The idea of the magic door makes Natalie and me excited about the new workshop activities, yet the students' excitement about the magic door did not pass on to the next class. Every class begins as if the agreements of the previous session have been forgotten.

One main reason is that there is an academic module change in Student's schedule during my fieldwork. Some students switch to a different class in the second half of the semester, including Brook, who initiates the magic door project. Meanwhile, some new students, for example, Mason and Ryder, join the class without knowing the origin of the magic door idea. Moreover, the leadership class is flexible and open; occasionally, some formal class members dropped in to the class to hang out. Therefore, different groups of students showed up in the workshop, making the collective decision or creative idea hard to carry forward from week to week.

Another reason is that students have so many creative ideas and throwing out fun ideas is part of their socializing; therefore, new ideas come up every class that steer the direction of the magic door project. During the workshop, Natalie burst out with questions, "So, where did the idea of the magic door come from? I don't remember?" Madison replied, "None of us remember anything." Murphy explained that the magic door is about creating a room that makes you feel secure. The magic door project started from Brook's door of imagination to Murphy's interpretation of the room that makes you feel secure, and at some point, Mason said it's the door to a place that can release your inner beast.

Nevertheless, the magic door project remained the workshop's main theme. I would explain the project's purpose and reiterate the design prompt in the beginning of every class, and student keep on working on the magic door with their own understanding. Eventually, the magic door became a general drawing exercise. Some students added magical elements to the door, some put on drew their favorite anime characters, and some express their deeper feelings about identity.

5.2.1 Magical Wind Kick-Off the Drawing Activities

The first "magic door" section started cold, in contrast to the heated discussion in the last class. People staring at the white canvas, not sure where to start, and saying they are not much of a painter. To inspire and encourage student, Natalie asl a question to heat up the classroom:

Natalie: Audrey what do you want for a magic door?

Audrey: nothing

Ryder: oh, it's a magic door! (Ryder just realized)

Natalie: What feels like a magic door for you?

Audrey: Nothing

Natalie: Can you answer the question, Audrey?

Audrey: No

Natalie: What feels magical to you? Can you answer the question? What feels magical to you?

Audrey: No.

Natalie: Nature?

Audrey: Killing

Natalie: Animals?

Mason: Ghosts

Natalie: Wind?

Audrey: No

Aspen: Yeah, let's add wind.

Bailey: Wind? Why do you want wind?

Aspen: Because are pretty magical. Because you can never see it.

Natalie: That feels magical to me too [8]

Aspen used a brush and blue color to create a big stroke with an airy texture, Figure 5-3, and further speculated that the wind can also be an ocean, and just like that, the drawing process started.

Students did not necessarily continue what they created from the previous weeks; sometimes they drew independently, other times they responded to the work already on the canvas. Authorship is not held tight in the magic door creations. Each drawing became a new starting point, a small, self-contained journey, and occasionally overlapped with other people's works. For example, Aspen began the drawing the wind and the wind gradually transformed into an ocean with alligators and eventually expanded into the sky with stars.

In the following workshop, Natalie layered doodling lines over Aspen's wind. In the other class, Madison merged the blue sky into a greyish limbo. The magic wind morphed into

[8] Conversation in Ann Arbor Academy during magic door project, April 3, 2024.

many different things, and people who were involved in this journey did not really care about the change of the authorship.



Figure 5-3: Aspen used brush and blue paints to draw winds.



Figure 5-4: Natalie uses a color pen to draw lines on top of Aspen's wind.



Figure 5-5: Margaret painted a gray-ish area near the wind.



Figure 5-6: The wind section on the final door.

5.2.2 Door to a Place for Hanging Out

Even though the drawing topics changed from day to day and were overlaid when people swapped seats, what remains consistent is the supportive space they created for themselves.

This sense of continuity was reinforced through a familiar class routine. Each session began with a discussion about what music to play in the background. Once everyone settled into their drawing practice, Robin, the school counselor, initiated a check-in process, during which

students shared what was new in their lives and how they were feeling. This practice functioned as a structured way for students to practice communicating their emotions and responding to other people's feelings, no matter how big or small, as a form of care.

The content of these check-ins varied. At times, students shared light, everyday frustrations, such as: "My parents got a new smartphone, so I inherited the old phone. I feel it's unfair, I want a new phone too." At other moments, the conversations were more serious and vulnerable, for example: "I went to see my psychiatrist and found out I have delayed sleep phase disorder. It basically makes a person want to go to sleep later and wake up later… Technically, there is nothing wrong with being nocturnal. But society isn't nocturnal. It's just me."

Occasionally, these conversations escalated into conflict, emotional breakdowns, or bipolar episodes. Rather than disrupting the space, these moments became part of the collective work of being together. Students learned how to apologize, how to repair relationships, and how to support one another in their low, reinforcing the classroom as a space not only for creative practice, but also for care.

Participation does not always take the form of visible production or verbal articulation. For example, Audrey, chose not to engage in drawing or speaking during the sessions. She consistently declined to respond to my questions and also did not respond when teachers asked her to share how she was feeling. While she seldom picked up drawing materials, she always remained seated with the group, listening to the ongoing conversations.

Occasionally, the conversation becomes quite heated, making it difficult to interrupt and gather the data I am looking for, for example, asking why a student chose a particular element for the magic door. After a few attempts, I realized that many students' attention had already shifted away from the magic door; for them, the activities had evolved into simply "something I like, "slightly deviating from the original prompt. The magic door becomes the backdrop for their weekly gathering.

Even when I paused the activity to ask students why they made particular design choices, with the intention of connecting their actions to sensory space, neurodivergent identity, or theoretical categories relevant to my research, their responses did not always produce the kind of explanatory insight I was seeking. For example, I saw Ryder drawing a spider web on the canvas. I asked Ryder, "Was the web meant to catch something?" Ryder responded simply, "No, I just drew a spider web. I think they're fun to draw. I don't really want to catch anything."

This simple answer resonates with many of the responses related to fidgeting or sensory stimulation that I observed throughout the fieldwork at both sites. Much of what the students do appears to be guided by what feels intrinsically satisfying or comforting in the moment. Even when the action meets a sensory need, they often describe it simply as something that "feels good" or that they "like," without offering a specific reason. For many, these preferences are difficult to articulate, or they just did not think about it too much, and do not understand that as a" sensory need" in the terms assumed by my research framework.

Besides the check-in led by the counselor, students often engaged in open-ended conversations that moved freely across topics, from questions about English grammar to whether Taylor Swift could be considered a cult leader to debates about whether their high school history textbooks still carry colonial legacies and to discussions of queerbaiting in television shows.

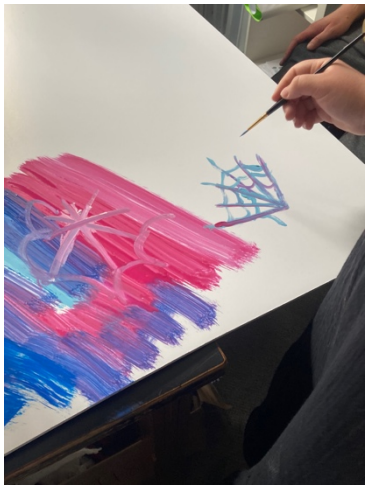


Figure 5-7: Ryder drawing a Spider Web



Figure 5-8: The final spider web on the magic door.

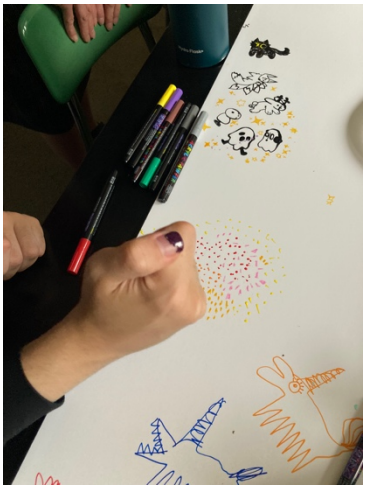


Figure 5-9: Aspen was focused on making many dots with the markers, trying to destroy the color pen's tip, trying to leave hand marks with paint, or tracing their hand profile on the canvas.



Figure 5-10: Aspen doodling while chatting with the group.

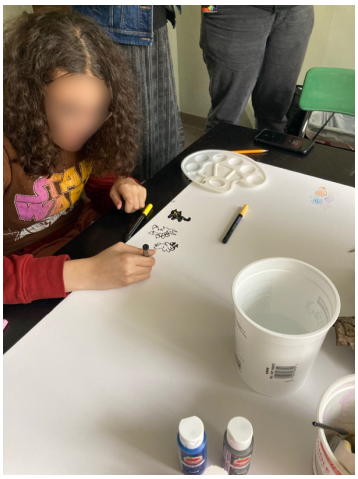


Figure 5-11: Bailey draw their favorite anime characters, Pokémon, or some non-binary character from the video game they play.



Figure 5-12: Aspen leaving handprints on the magic door.



Figure 5-13: Aspen leaving handprints on the magic door.



Figure 5-14: Robin traced Aspen's hand on the magic door.



Figure 5-15: Skyler collecting tree bark for magic door.



Figure 5-16: Skyler's drawing on the magic door.

5.2.3 Door To a place that accommodate multiple material practice

Even though Audrey did not often participate in sharing her thoughts or feelings and particularly didn't like to answer my questions about sensory space. She remained present in the room, waiting for opportunities to participate in the format she preferred. When we are making collage, the thing that exists behind the magic door, she found her passion.

Audrey stared at the knit with orange and blue flaps for a while and she yelled, "We need eyeballs; yes, that's what we need." Skyler, sitting across the table, shouted out, "I have googly eyes! I have googly eyes on me at all times." Skyler not only has some googly eyes, but he also has a pack of them with different varieties. Skyler brought googly eyes with him to school every day, and he was so happy it comes in handy eventually.

Aspen and Audrey carefully attached the googly eyes to the knit using a hot glue gun, making sure not to leave any residue on the textile. While working, they noticed some mesh tubes nearby and thought they could serve as legs. This led to the idea of turning the piece into a caterpillar, characterized by multiple eyes and legs. To finish it off, Audrey painted the end of the knit in bright pink, imagining it as a tongue, giving the caterpillar a playful touch. They named their many-eyed, many-legged friend Bob, Figure 5-17.

They are having lots of fun sorting the googly eyes, deciding where and how many googly eyes should be, and naming the creature. Audrey usually doesn't respond to my questions, rarely participates in activities, or shares her opinions. She mostly talks to her friends,

and when I ask things like, “What do you like about this knit?” or “Why did you pick that color?” she often just laughs and says, “No.” According to Natalie, both Aspen and Audrey are usually quiet and tend to avoid group activities or discussions about their thoughts. But in the workshop, something changed, they talked and laughed more.

When designing the flap knit, I aimed to create a stateful material, one that offers multiple stable configurations for users to interact with. The flaps can be flipped up and down or side to side, allowing the knit to shift both visually and tactilely. Flipping the flaps to the opposite side changes the overall color shade of the textile, and running a hand across the surface evokes the sensation of touching a textured, voluminous material. However, Aspen and Audrey perceived the curly flaps differently, seeing flaps as body segments of a creature. They engaged with the knit in ways I had not anticipated, and it open a space to play with friends and physicalize their imagination which the material they like.

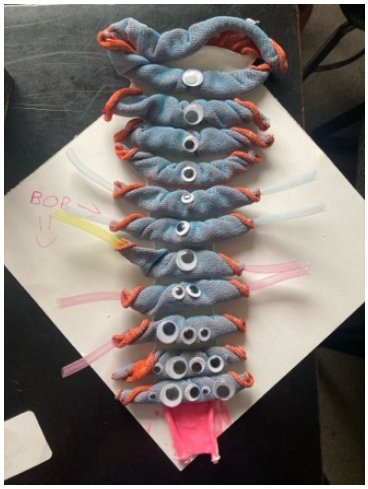


Figure 5-17: Bob, created by Aspen and Audry.

Not only did different students attend each workshop, but the number of participants also varied from week to week. On some days, only three students came, on others, as many as seven attended. When the group was large, along with a classroom teacher, a school counselor, and me, the room could barely accommodate everyone, in addition to the large canvas and art supplies. These fluctuations shaped how participation unfolded, requiring the activity to remain flexible rather than fixed.

As April arrived and the weather warmed, spatial constraints prompted students to expand beyond the classroom. When the room could no longer comfortably hold everyone, students began to disperse into adjacent areas. Some worked on casting doorknobs in the

common space, Figure 5-18, while others experimented with casting textures from nature, applying plaster to rocks, sticks, and tree bark, Figure 5-19 and

Figure 5-20. In this way, students contributed to the “magic door” through different materials and modes of making: some drew directly on the canvas, while others produced plastic forms or textured casts that were later glued onto the door.

From a participatory design perspective, these varied contributions reflect agency expressed through choice of medium. Students selected materials that aligned with their interests and comfort levels, whether drawing, molding, casting, assembling, or just chatting by the side and suggesting what color to use. This plurality of materials also functioned as an accessibility strategy, enabling participation beyond a single dominant mode of expression and accommodating different sensory thresholds and energy levels.

On certain days, students arrived full of energy and excitement, ready to immerse themselves in the activity. Often, one student would spark an idea that quickly spread through the group, drawing others into a spontaneous collective experiment. One day, Madison and Natalie were very into touching paint, making a rebellious mess. They drew with their bare hands, made handprints, Figure 5-22, smeared paint across the surface, Figure 5-23, and used strings to drag pigment around, Figure 5-21, creating new textures and marks. They even dragged Aspen, who usually dresses very nicely and doesn’t like messiness, to the scheme.

The idea of the “magic door” stepped into the background. The canvas became an open-ended participatory surface. Throughout the process, students continued talking, listening, and responding to one another with their hands in constant motion. Making became a deeply sensorial, collective form of participation.



Figure 5-18: Plaster casting on a doorknob.



Figure 5-19: Students collected rocks from outside and applied plaster onto them.



Figure 5-20: Students casting plaster on found stone.



Figure 5-21: String drawing.



Figure 5-22: Hand printing.



Figure 5-23: Madison smearing paints with hand



Figure 5-24: Drawing with hand stamps

5.2.4 Door to a Place for Expressing Feelings

At the Disability Network, crafting activities often result in highly personal, narrative-driven artworks, such as Kelly's casts or Susan's mind maps. The creative process with adults tends to be more solitary: participants usually come to class, work independently on their pieces, and leave. By contrast, crafting activities at Ann Arbor Academy are more social and communal. Many of the drawings depict everyday things or students' favorite popular culture icons. While students frequently discuss topics related to identity and political issues, very few of these themes are directly reflected in the artwork itself.

Murphy carefully cut out scrap material to illustrate the dinosaur head and leave a note to describe her imaginary world: A place where dinosaurs will eat all men, and women will be in charge, Figure 5-27.

Aspen carefully sorted the scrap yarns by color and filled the canvas with rainbow colors, Figure 5-25. Murphy delivered the message through text and the collage dinosaur head, while Aspen chose to use the rainbow as a cultural symbol to express her queer identity. While Aspen was carefully sorting the tangled colored yarn and placing them, I asked Aspen what the collage wanted to say and if it meant anything in particular. She said this messy, tangled yarn represents the messiness in her life.

> Yi-Chin: And what about you, Aspen? Why the rainbow threads? Why do you want this behind the magic door?

Aspen: Because it reminds me of myself. A mess.

Yi-Chin: A mess?

Audrey: You're not a mess, Aspen.

Aspen: Yeah, I am.

Audrey: Not.

Aspen: You don't know that.

Mason: I'm a hot mess when I'm in the mornings.

Audrey: Yes, I'm a hot mess, too.

Mason: Like, I woke up from a. I woke up from a bad dream, and then I went downstairs, my parents got new phones, and I was like. I was like, girl, I thought it was, like, some sick ass drama…[9]

In these two very personal pieces, Aspen and Murphy used scrap materials to construct clear messages, whether through text or color. I sometimes tend not to poke too deeply into participants' personal lives. I am not sure when the unstructured interview will invade privacy, and I am also not confident I can catch any fragile emotions or handle difficult conversations, especially when working with high school students. Yet seeing students support each other and engage in the difficult conversations in a gentle and humorous way makes me feel heartened.

[9] Conversation in Ann Arbor Academy during collage workshop. May 2, 2024.

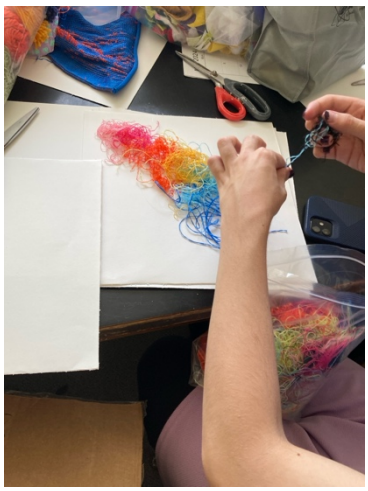


Figure 5-25: Aspen working on her rainbow threads



Figure 5-26: Aspen's rainbow yarn collage.



Figure 5-27: Murphy working on her sketches.

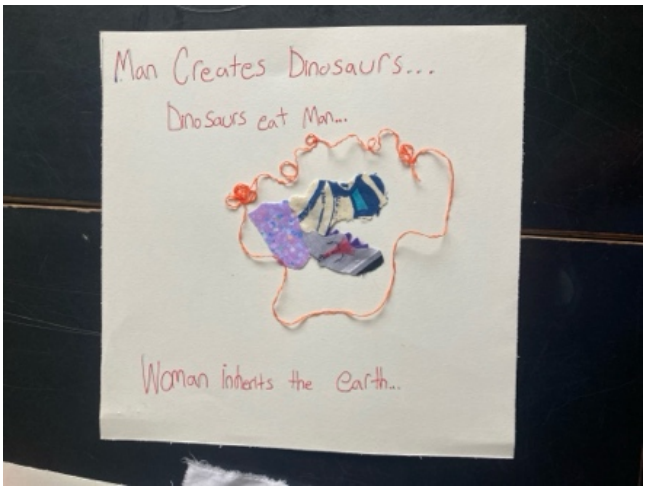


Figure 5-28: Murphy's collage

5.3 Conflict

Even though students build a collaborative and peaceful space to share, sometimes conflict happens.

In one drawing session, I encouraged students to experiment with different media, such as colored pencils, markers, paints, brushes, and even stickers. I also provided gloves for those who wished to explore smearing paint directly with their hands. The "smearing" technique refers to a drawing method that involves applying and manipulating paint with the bare hand directly on the canvas to create soft transitions and blurred effects. Offering this drawing option was

inspired by the art workshop at the Disability Network. Claire, the art class director, introduced this approach as an inclusive method for participants who found it difficult to control a pen or brush. By inviting people to use their hands, the method centers tactile experience and celebrates the sensory qualities of paint and paper, to feel its texture, friction, and resistance, as part of the creative process.

When I introduced the idea of smearing, Madison's eyes lit up with excitement. She has a playful and exploratory personality, often expressing enthusiasm for hands-on and bodily forms of engagement. As she often says, she "likes to be messy." Within minutes, Madison poured paint directly onto the canvas and began pressing and spreading it with her hands. Some students join the smearing with gloves, while Madison chose not to wear gloves, and wanted to have all the color on her hands, Figure 5-29.

At one point, a single slap of paint became too strong. The paint, already quite liquid, splashed across the table, onto the wall, and over everyone nearby. It splattered on clothes, even on faces. The room erupted in laughter, students screamed, laughed, and called out "Madison!" Madison found it hilarious and laughed along with the group. But as the laughter subsided, we began to notice that Mason was not amused. Paint had gotten on their clothes, and they looked very upset.

Mason is also curious and has an outgoing personality, yet they are particular about certain sensory experiences. They dislike people sitting or walking past them behind their backs, and always wear gloves to avoid direct touch, along with long sleeves and pants that cover their skin. Their sensory preferences stand in sharp contrast to Madison's. While Madison seeks sensory engagement through movement and touch with every inch of her skin, Mason prefers to manage and minimize direct contact.

As Mason realized their shirt was stained, their mood shifted quickly from mild irritation to visible distress. They worried their clothing was ruined and that their plan to visit the bookstore after school was now impossible because they were, as they said, "messy and covered in shit." Mason asked Robin if the school could call their parents to pick them up, but Robin gently declined and said, "I think you can handle this."

The group began to sense the tension. The laughter faded as everyone became aware that the moment was no longer playful. Gina took Mason to the bathroom to help clean their clothes. Ryder Murphy tried to comfort Mason, saying things like, "I like my painting jumpsuit covered

in paint," and "Yeah, my headphones are always messy because I wear them in the kitchen." Meanwhile, Natalie went to find Mason a new pair of gloves.

As Mason's distress deepened and attention centered on their situation, Madison's mood shifted. Her earlier excitement disappears. She seemed unsure how something that had felt fun only moments ago had become so tense. With everyone now focused on Mason, Madison appeared to feel responsible, and she had done something wrong. Soon, she began to cry. The classroom fell silent. No one spoke loudly; the air felt still, and everyone seemed to be waiting for the discomfort to pass.

The conflict observed here emerges at the intersection of sensory preferences and interpersonal dynamics. Margaret prefers direct, bodily interaction with materials, while Maisie insists on engaging with everything through a layer of gloves. While this difference may appear to be about sensory experience alone, it is also deeply entangled with the everyday group dynamics of high school students. They play, argue, and negotiate boundaries; conflicts arise, dissolve, and are often repaired by the next day, when they return to being best friends.

This moment highlights the complexity of working with people in community-based and participatory contexts. Community participation is not always harmonious or pleasant; participants bring emotions, personal boundaries, histories, and tensions into the space. Conflict is not an exception but part of everyday social life. From a CBPR perspective, attending to and holding space for conflict, rather than attempting to smooth it over, becomes an integral part of the research practice itself.



Figure 5-29: Madison playing with ink happily.

5.4 Installing the Doors

After four workshop sessions across April 2024, we finally completed three magic doors. Throughout the workshop, students produced six canvases using 48” x 32” foam core boards. I collected all the painted canvases and brought them to the University of Michigan woodshop to assemble them. In the woodshop, I used a nail gun to attach each canvas to a custom-made wooden frame and sourced some ready-made door accessories and attached them to the frames to make it look like actual doors.

On installation day, the final session of the workshop, we gathered all the collages to install behind the wall. These collages were created by students in an earlier session, where I invited students to use the knits and soft materials provided to make mixed-material collages in response to the prompt, “What do you want to see behind the magic door?”, “What texture is there in your perfect sensory environment?” I discussed the details of the collage workshop with an emphasis on human agency in Chapter 4.

As we began setting up, several students added last-minute touches to the door. Ryder left a final purple handprint, and a few others asked if they could glue their plaster casts onto the surface as decoration, including casts of their hand gesture, tree branches, and stones. When we arranged the collages, we realized that the combined pieces covered only one wall. In response, Margaret suggested drawing a tunnel on the wall behind another door, and Brook quickly joined her. Both became deeply engaged in this spontaneous expansion of the project, their focus shifting from door installation to wall painting, a classic move for this group, reflecting their openness to follow curiosity wherever it leads.

Another interesting incident happen during the installation is that Madison uses red paint and presses her palm print on the door, and adds "hel", Figure 5-29, wanting to make it like a horror story where people use their bloody hands to scratch the door when they want to get out. Madison was proud of her work, and me and Natalie are also very support student being creative and houmous about the door. However, the door will eventually be placed in the common area, and Robbin don’t think its appropriate to displace this type of message, so she clearly added "lo" and made it "hello" to comply with the school's language policy, Figure 5-38.

Observing students making all the art works, I was reminded of how fluid the boundaries of the workshop activities had always been, how easily the students moved between structured tasks and improvisation: from body casting to handle casting to the magic door; from door

installation to painting a tunnel on the wall. What began as an installation task evolved into another moment of play and collaboration. The process, rather than the product, remained the most meaningful part of their engagement.

Properly anchoring the door onto the beam required further assessment, as did the wall painting. When the workshop officially ended, the door had not yet been fully installed, and the wall was still pitch black. I returned five months later to find two out of the three doors finally mounted in the school's common space. Seeing it there, I was struck by how the project had taken on a life of its own, slowly merging with other activities happening in the space, yet continuing to hold traces of the time we spent during the workshop.

September 2026, roughly a year after the doors were installed, Natalie contacted me to pick up the doors because they are reorganizing the space, so they need to take down the doors, which marks the end of the magic doors.



Figure 5-30: Margaret and Bailey working on the wall painting. They painted the wall black and plan to draw a tunnel on top of it.



Figure 5-31: Hooks on the door



Figure 5-32: Hinges



Figure 5-33: Door stopper



Figure 5-34: Three magic doors



Figure 5-35: Robin attached the plaster casting of a tree branch on the door, and added colors

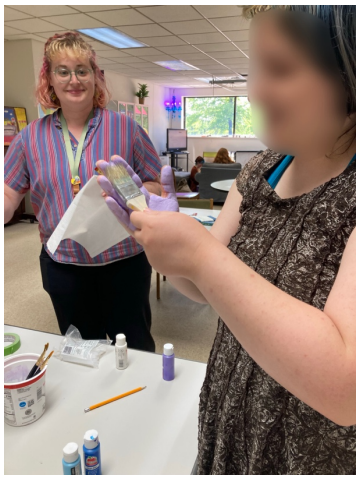


Figure 5-36: Ryder left handprints on the door as signage.



Figure 5-37: Ryder's handprint and signature.



Figure 5-38: After five months, I returned to the Ann Arbor academy, the magic door is blended with other posters on the common area wall, with a table and chair sitting in front of it.



Figure 5-39: Collage behind the door.



Figure 5-40: Collage behind the door.



Figure 5-41: Magic door.



Figure 5-42: Natalie open the magic door.



Figure 5-43: The tunnel behined the magic door.

5.5 Coexisting with Uncertainty

The Magic Door project evolved through interactions, negotiations, and reinterpretations among students. Initially, I experienced this gap as a methodological failure, that I did not do my homework enough to come up with a plan they would definitely enjoy, or I was not confident enough as a researcher. Over time, however, this misalignment became analytically productive. At first glance, these activities may appear distant from computational design practice, as the process did not involve algorithms, predefined parameters, or digitally controlled machinery. However, the process of constructing magic doors can be understood as a form of world-making in which language, interpretation, and collective negotiation operate as generative structures that actively shape the design in each workshop section.

This perspective points to two considerations. First, how might the communication process between researcher and participants be designed so that collaborators can ensure they are referring to the same concepts and intentions? Or if that is not possible, how can the work aim to reach a version of a world that is "close enough" to each participant's own? Second, how might computation be understood not only through fixed rules, but also through dynamic interpretation and the ongoing construction of worlds as the relationship between humans and their built environment evolves? Magic doors also revealed blind spots in identity-based research and challenged my assumptions about what kinds of data ought to be considered relevant. These lingering questions point me to explore the concept of world-building and engage more deeply with qualitative analysis to work with the uncertainties that arise in this collaboration, ultimately resulting in a diagram that captures this fluid process.

The Magic Door project illustrates a central feature of community-based participatory research: uncertainty. This uncertainty mainly comes from students' evolving interpretations of what is magical and what consider sensory space, as well as student's attention, priority and interests change along the course of our collaboration. These factors functioned as parameters of a sort, but they were neither stable nor readily legible within dominant computational design workflows, which typically begin with predefined, quantifiable variables, a fixed problem space, and a clear path from input to output.

Linguists Michael J. Reddy proposed the concept of Conduit Metaphor, which highlights how language is often treated as a conduit for exchanging fixed meanings, rather than as a flexible, context-dependent medium shaped by interpretation and negotiation. This insight is

particularly relevant for collaboration across discipline or worldviews , where the alignment of understanding among participants is never guaranteed and meaning emerges through interaction (Reddy 1993). Complementing this, philosopher Nelson Goodman's theory of worldmaking emphasizes that humans construct multiple, overlapping worlds through symbolic systems, including language, art, and design practices, and how we "know" resulting from constant communication between different worlds (Goodman 1975).

Language might be too abstract to think about worldbuilding in the design context. Within computational design, shape grammar provides a formal framework for generating and transforming visual elements through rule-based operations, yet even these "formal" systems rely on interpretation, selection, and iterative adaptation by designers (Knight and Stiny 2015). In the context of the Magic Door project, every time we gathered, different students showed up, brought in new thoughts of the week, different music played in the background, the upcoming school events or even the weather of the day could shape that one-hour crafting session, and a new understanding of the door developed. The process of building magic door is drastically different with conventional computational design process that usually have relatively clear objectives, or a problem space to solve.

I entered the fieldwork carrying this computational design mindset, alongside a desire to identify a potential application or concrete outcome at the end of the project, which generated moments of tension, mismatch, and confusion. Attending to this mismatch highlights the importance of investing effort to translate "feelings" and integrated it to computational design practices without reducing them to fixed or legible parameters. In participatory research, plans often fragment or dissolve over time. The challenge is not to enforce stability, but to make sense of what is going on, and pay attention to what participants may want to share. All the information may not be useful to the predefined questions, but they are all helping me to understand the participant as a human, refine the initial questions, or ask other questions. Within this framework, the designer's role shifts away from problem-solving toward facilitation and translation between worldviews. In doing so, designers can contribute tools and design activities that mediate among human experience, material engagement, and computational processes, ultimately positioning computational design as a service rather than merely a tool to generate tangible products.

Another important finding is that although disability or neurodivergence functioned as a shared point of connection among participants, it did not account for all aspects of their decision-making. Adult participants' mind maps suggested that loved ones, memories, and personal interests played a significant role in how they imagined and selected sensory spaces. Similarly, among students, social relationships, individual dispositions, and influences from popular culture often shaped their material preferences and design choices. These influences were no less consequential than neurodivergence, and lots of time they were harder to formalize.

There were moments when participants explicitly linked their engagement to sensory processing, such as when Felix described his attraction to repeatedly flipping the curly edge of a knitted surface. At the same time, it is important to acknowledge that each participant is a complex individual whose actions emerge from multiple, intersecting factors, many of which remain outside my awareness and beyond the scope of this study.

Taken together, these reflections underscore the limits of interpreting participation primarily through identity categories or predefined evaluative frameworks. Instead, they point toward the importance of attending to contexts. To generate knowledge from participatory design requires learning to coexist with uncertainty, recognizing that not all forms of engagement can or should be precise, and that meaning often emerges through sustained practice rather than measurable outcomes.

To support this approach, I present a process diagram, Figure 5-44, that outlines a design process intended to be transferable to broader computational design practice. The upper diagram is for a more generalized approach to designing an inclusive material system, and the lower part, with illustrations, is based on my research context, working with neurodivergent individuals to study the tactility of a knitted material system. The process is iterative and may require multiple cycles before reaching the research goal. First, designers identify the material system they intend to develop and study its behavior, design space, and fabrication capacity. Second, designers establish a communication method that both researchers and participants find accessible and engaging. This method may include craft-based activities, focus group discussions, or photovoice[10].

[10] Photovoice is a participatory method where participants take photos to document and discuss their experiences, helping researchers understand their perspectives.

Next, the material system or prototypes are introduced through this communication channel, and participants' engagements are documented. Feedback may emerge in multiple forms, including verbal reflections, material engagement, or social interactions. The collected data are then analyzed using qualitative methods to organize and interpret the responses. Some feedback may directly inform adjustments to the material design itself. Other insights may help designers reconsider or reprioritize design goals. Still other forms of feedback may not directly address the initial design question but provide insight into participants' broader experiences and perspectives. These insights help designers better understand the community context and identify new questions for further inquiry.

As St. Pierre and Jackson notes, in qualitative research, there is no single "right" path each researcher's process, the methos are shaped by their individual perspective, circumstances, and the research context (St. Pierre and Jackson 2014). Following the same approach may not produce the same outcomes; what follows is offered as one illustrative example.

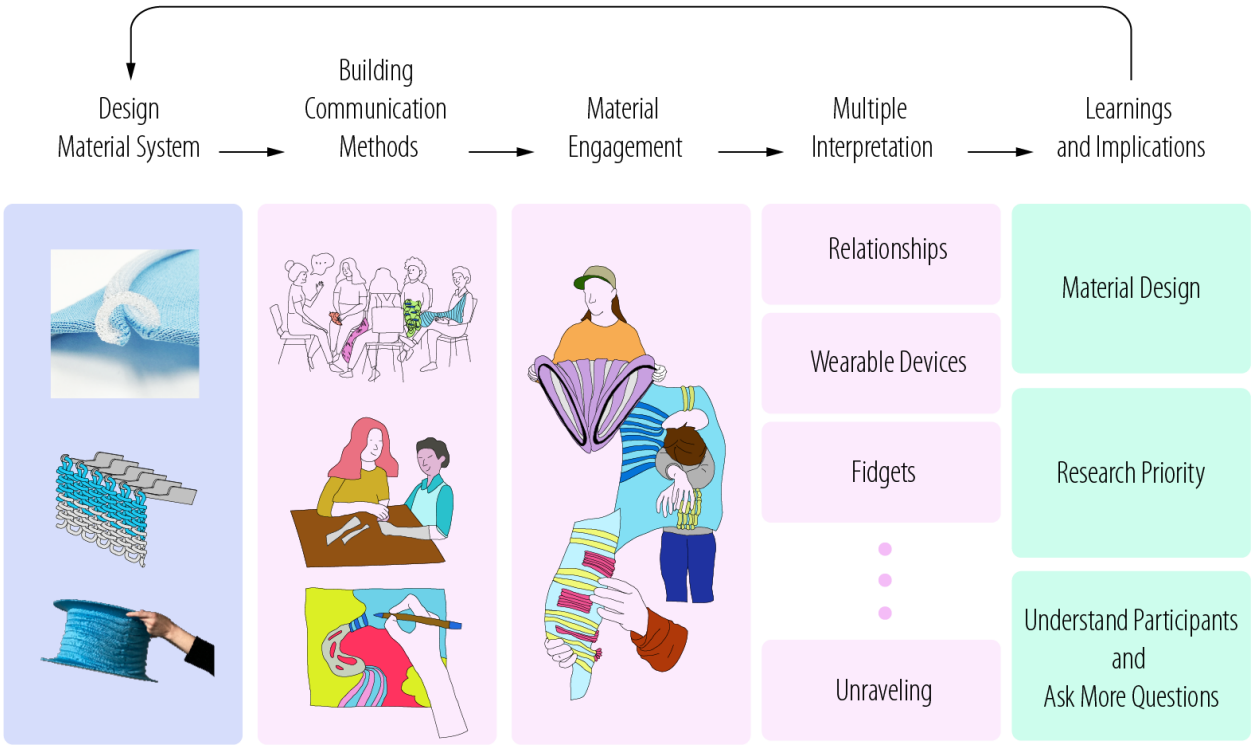


Figure 5-44: A reflective diagram that capture the possible workflow.

Chapter 6 Conclusion

The final workshop with the Disability Network took place at Taubman College of Architecture and Urban Planning. The visit was arranged at the participants' request. Throughout the project, they had expressed curiosity about the knitting machine, how the knits were made, what the machine looked like, and how this seemingly "magical" device translated code into material. Visiting the lab was meant to be a moment of closure, a chance to see the process behind the artifacts they had worked with over the course of the art making workshops.

On the day of the visit, two participants arrived using A-Ride, the city's shared accessible transportation service. Others drove themselves to the university. Before the lab tour even began, parking emerged as the first obstacle. There were few accessible parking spaces near Taubman College, and those that were available that the moment required navigating a sloped path to reach the building. For a wheelchair user, the slope was steep. For Caroline, who uses a walker, it was manageable, though she said that it counted as her exercise amount for the whole week. Participants without disability parking permits struggled with find an open spot on a school day.

Although I had tried to anticipate the accommodations needed for the lab visit, I overlooked parking. Because I do not commute by car, I was unaware of how difficult parking on campus could be, and I was not very helpful in that moment in identifying nearby options or explaining how to pay when the ticket machines were not functioning. With limited time and a full schedule ahead, the group made a collective decision: everyone parked wherever they could find a space and expected they will get a parking ticket. I later collected the ticket and paid the fines using research grant funds, treating them as an unanticipated but necessary cost of participation.

The most unfortunate situation involved Jasmine. Disoriented by the parking instructions and unable to find a parking spot, she eventually drove to the VA hospital nearby and parked there instead. She was frustrated and wouldn't pick up the phone when we call her to point direction. She ended up wandered in the hospital, unsure of where to go next. She never made it to the lab tour, the final workshop, or the concluding interview. That day marked the closure of the participatory research with the Disability Network; however, Jasmine's absence stayed in my

mind for a long time and did not have a closure. I was mindful that she was navigating her own challenges, including a previous moment in which she expressed distrust toward my research intentions. Considering the failed lab visit, I worried that this experience may have reinforced feelings of mistrust toward university-based research.

After the event, I emailed the DEI office at Taubman College to ask for guidance on hosting group of visitors with disability who need accessible parking. I described the parking challenges and pointed out that the designated accessible parking on Fuller Road still required individual crossing the lot and navigating a ramp to reach the building, increasing physical effort and distance. After finishing the dissertation, I revisited the Fuller Road parking lot to check the accessible parking situation. I noticed that the accessible parking spaces had been removed, and a sign at the ramp entrance stated, “NOT ACCESSIBLE, ”as shown in Figure 6-1. I assume the accessible parking may have been relocated to the street-level entrance; however, this information has not been updated on the Art and Architecture Transit and Parking page. At times, I wonder whether there were valid reasons for Jasmine’s lack of trust in me, or in university-based researchers more broadly. It is difficult to ask participants to place confidence in institutions that claim to produce research intended to support their lives, when basic issues of access, such as parking and navigation, remain significant barriers.



Figure 6-1: The new sign added to the ramp from the Fuller road parking lot to the Art and Architecture building indicates that the ramp is not for accessibility.

The parking issue returns me to the dissertation’s initial research question: How can neurodivergence orient and reshape computational design practices. Before attempting to “reform” computational design itself, this moment suggests the importance of attending to everyday practices of care, small gestures such as accessible parking and navigation, that help people feel welcomed into the campus, the conversation, and the design process.

These moments reveal that community-based participatory research is not sustained by well-designed technical solutions or well-organized design workflows alone but is continuously carried through relational practices: being reflexive, remaining flexible, and being kind to one another. The findings across the chapters respond to this shared human-centered value, arguing that it is not new or "shiny" technological tools that enable computational design to better support people's needs, but the research methods that encourage listening, attending to participants' lived experiences, and valuing those experiences as a legitimate source of knowledge within computational design.

Chapter Three concludes that while computational design excels at precision and efficient scalability, these strengths do not necessarily translate into emotional or sensory support for neurodivergent individuals. In such contexts, smaller-scale artifacts may be more appropriate, as they invite intimacy, flexibility, and personal meaning rather than optimization. Chapter Four further demonstrates, through participants' material choices in their artwork, that precision as a computational aesthetic can be intimidating and may create barriers in participation. Allowing free modification, improvisation, and even destruction can encourage greater agency and generated richer forms of feedback. Chapter five shows that participatory work rarely unfolds as planned. Moreover, although computational design often values tangible outcomes or finalized solutions, the story of magic doors reveals that participants cared more about the process of making, building together, crafting small personal corners, and claiming space, than about producing a singular, perfected artifact for exhibition.

Taken together, the finding chapters highlight tensions between community-based participatory research and computational design practice. The dissertation concludes that computational design, and machine-knitted sensory artifacts in particular, function as a double-edged sword. On the one hand, they enable highly tailored designs that respond to individuals' unique bodily and sensory needs. On the other hand, their precision, flawless, and controlled aesthetic can signal closure, making the design appear finished and discouraging further conversation, negotiation, and participation.

This dissertation contributes to the field of computational design by reframing participation, care, and lived experience as central, rather than supplementary to computational design practice. Through customized participatory research methods and a technical exploration of machine knitted material as a medium for sensory support, the work demonstrates how

neurodivergence can orient computational design toward a human-centered modes of knowledge production.

There are several limitations that shape the findings. First, the sample size across the studies was limited, and participation, particularly at Ann Arbor Academy, was unstable over time, affecting continuity and the ability to draw insights from sustainable engagement in the individual level. Second, the findings are situated and context-specific, therefore are not intended to be generalized across all neurodivergent populations. Additionally, my positionality inevitably influenced the research process, including design aesthetic, facilitation style, and interpretation of participants' responses. While reflexive practices were used to attend to these dynamics, personal bias cannot be fully separated from participatory engagement. These limitations are not presented as shortcomings to be corrected, but as conditions that reflect the realities of this work.

Future work will explore collaborations with art therapy specialists to investigate tactile making as a nonverbal modality for communication, healing, and communal care. Moreover, expanding the qualitative methods with quantitative approaches to provide measurable metrics in knit design, supporting a more rigorous exploration of tactility. Current design tools tend to prioritize visual and structural stability and integrating quantitative measures could help capture the nuanced sensory qualities of knitted materials, and for better communication among designers. Finally, future research could explore more accessible knitting tools that enable participants to design their own textile wearables using a wider range of everyday materials. This would reduce reliance on industrial flat-bed knitting machines and shift the role of the designer from gatekeeper to facilitator, expanding creative possibilities and participation.

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