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TOUCHSTONES

DESIGNING TACTILE COMMUNICATION

2026 MASTER OF DESIGN

DIGITAL FUTURES

TOUCHSTONES:

Designing Tactile Communication

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A thesis exhibition presented to OCAD University in partial fulfilment of the requirements for the degree of Master of Design in Digital Futures in 2026

OCADU Waterfront Campus, 130 Queens Quay East, March 26 – 30th
Toronto, Ontario, Canada, 2026

ABSTRACT

Touchstones is a design research study which explores how design methods for haptic devices might expand non-verbal, tactile communication amongst friends and loved ones. While many current forms of digital interaction rely on video calls, messaging, or large-scale social media platforms, this project investigates how vibrotactile feedback within intimate, platonic networks might offer alternative forms of connection and communication.

Iterative prototyping and an exploratory workshop series inform the design and development of “Touchstones”: stone-like, handheld, wireless, and networked devices equipped with vibration motors. Each iteration refines the Touchstone ecosystem, including physical devices, haptic interactions, and a graphical user interface through which users create, send, and receive tactile communications. Insights from the workshops are applied to the final iteration, shaping how the Touchstones form a bespoke communication system within group social contexts.

Touchstones are designed for group-based haptic communication, building upon commonly seen one-to-one explorations. Using a Research Through Design methodology, *Touchstones* draws on and contributes to areas of study including embodied interaction, mediated social touch, and nonverbal communication devices. The prototypes and insights generated through the workshops and iterative making process offer design knowledge for how tactile communication can augment social connections and function as a meaningful shared communication system within social groups.

Keywords: *haptics, tactile communication, mediated social touch, non-verbal communication, research through design, human-computer interaction, interaction design*

ACKNOWLEDGEMENTS

To my advisors, Kate Hartman and Fidelia Lam – thank you for your endless support, guidance, generosity, and enthusiasm. Your perspectives shaped this work and I'm grateful to have learned so much from you both.

To the talented Digital Futures community, and my sixth-floor studio-mates – thank you for your generosity in sharing knowledge and being a constant source of motivation and inspiration.

To my friends and family – thank you for all your love and encouragement, throughout this process and always!

To the participants of this study – thank you for your time, creativity, and willingness to "taste test" with Haptics Tapas.

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CHAPTER 1: INTRODUCTION

1.1 What are Touchstones?

Figure 1: The Touchstones system in use.

Touchstones are physical haptic devices with accompanying software for designing and sharing vibration patterns. The system emerged through an iterative prototyping, Research Through Design (RtD), and reflective design methodology. A series of four Touchstones prototype versions were developed over the course of seven months, investigating how vibrotactile feedback within intimate, platonic networks might offer alternative forms of social connection. The Touchstones system enables users to collaboratively design a communicative vibration pattern on a Graphical User Interface (GUI), wirelessly broadcast it to all holders of the physical haptic devices, and feel the pattern they designed emitted as a vibration sequence. The Touchstones name originates from their stone-like form, their tactility, and their aim to enhance “keeping in touch” with social connections.

The development of the Touchstones was shaped by my background in graphic and web design. I often work with web-based interactive systems, and as a result, I was drawn to approach haptic communication through a GUI alongside physical devices. The GUI offers a visible tool to design and share vibration patterns, while the physical devices provide a tangible and embodied point of reception (see Figure 1).

1.2 Motivation

When the COVID-19 pandemic began in 2020, many facets of human life moved online. Remote work, online shopping, and food delivery became the norm. Most forms of socialisation were reduced to FaceTime, Zoom, Teams, Discord and other screen-based applications. I graduated from high school with a socially-distanced drive through to pick up my diploma and began my undergraduate studies remotely. It was an isolating experience – to start what should have been an exciting opportunity to connect with new people while being physically apart from all people.

As someone who has always been deeply immersed in digital spaces, both as a child of the Internet and a web designer in training, starting university remotely deepened my interest in the ways we socialize online. Losing in-person interaction so abruptly made me reflect on how we connect with others when physical presence isn't possible. The question that guided me to this project is:

Can digitally-mediated social interactions truly replicate or replace in-person social connections?

At the start of this project, my curiosity specifically centred on how touch and presence might be mediated through digital systems. I became interested in the expressive qualities of touch, such as how it can communicate care, reassurance, attention, and even inside jokes without words. As haptic technologies advance across disciplines, many applications frame them as tools for simulating physical contact at a distance (ex. Bond Touch, 2025; Banerjee et al., 2025). However, this research does not seek to recreate touch in a literal sense. Instead, it explores how vibrotactile feedback might operate as a communicative medium in its own right, supporting shared meaning and social presence without attempting to replicate physical contact.

While many current forms of digital interaction rely on video calls, messaging, or large-scale social media platforms, this project investigates how vibrotactile feedback within intimate, platonic networks might offer alternative forms of connection and communication. My research seeks to contribute to a larger discourse of how we socialize and what makes communication fulfilling when physical presence is not possible.

1.3 Research Questions

1. How might personal haptic communication devices be designed to augment group social connection?
2. What tools enable tactile communication to function as a meaningful shared social messaging system within intimate, platonic networks?

1.4 Scope & Limitations

Within the scope of a single year master's level thesis project, there are limitations to what is possible to explore in a design research study. This project intersects many different fields and design approaches, spanning haptic technologies, remote intimacy, human-computer interaction, physical object design, user experience & interaction design, and sensory objects, but acknowledges that the full extent of these fields are not covered in this paper.

This project focuses specifically on how vibrotactile feedback within intimate, platonic networks might offer alternative forms of connection and communication. This area of interest is from my own personal motivation and was selected to meet a gap in research identified through the **Literature Review** and **Related Works**. Having a focused audience of intended users narrows the scope of the project to design for specific needs. Sexual remote intimacy, such as teledildonics, is not the focus of this research.

This project centres around bespoke haptic objects but is not inventing new hardware technologies. The core technical components required to generate vibration patterns and develop device-to-device communication networks already exist. Rather than developing novel hardware systems, the emphasis of this study is on exploring how existing technologies can be configured and designed to support emotionally resonant and meaningful tactile communication. The prototyping process therefore investigates different microcontroller systems and hardware configurations to identify a practical and appropriate technical stack for a small haptic communication device.

This project also iteratively explores the user interface to design communications through haptics with a foundation in existing works (see **Related Works**). The outcomes for the haptic communication design process focus on open-ended play rather than delving deeply into the history of pattern-making or assistive devices for communication, but brief context is provided in the **Literature Review**. While this project does not attempt to build a formal language, it investigates how tactile patterns can function as a communicative tool for conveying meaning between users.

1.5 Chapter Overview

Following the **Introduction**, the **Literature Review** introduces current literature and research in the areas in which this project lives in and expands upon: haptic technologies, digital intimacy, pattern communications, and sensory objects.

Related Works offers a specific review of related projects in the fields of haptic communication, social haptics communication, and the design of haptic feedback experiences.

Methods & Methodologies describes the research approaches and influences of this project, including iterative prototyping, generative design workshops, and embodied interaction.

Prototype Development outlines the making process, outcomes, and reflections of each prototype iteration. This is organized by the facets of development of the Touchstones system.

Haptics Tapas Workshop shares the facilitation development, data collection, outcomes, and reflections from the workshop series.

The **Conclusion** reviews the outcomes of the entire project and provides reflections on the resulting research contributions. The Future Work subsection offers direction for potential avenues of research resulting from this project.

CHAPTER 2: LITERATURE REVIEW

This literature review examines how contemporary haptic technologies are designed to support emotional expression and social connection in mediated environments. To situate this project within existing research, the chapter draws on foundational work from haptic technologies (Jones 2019; Parisi 2018; Schneider et al. 2017), research on digital intimacy and relatedness in mediated communication (Sadowski 2016; Hassenzahl et al. 2012; Balfour et al. 2025), and studies of social presence in virtual and digital environments (Oh et al. 2018). Additional literature examines pattern-based and assistive communication systems (Gleick 2011; Parisi 2018; Lu et al. 2025), which demonstrate how meaning can be constructed from patterns and nonverbal communication. Finally, this chapter considers perspectives from science and technology studies that examine emotionally affective and sensory relationships with objects (Turkle 2007; Liu 2025).

2.1 Social Haptics

Human beings are inherently social creatures – the ways in which we interact with each other may change and evolve, but ultimately we need interaction, connection, and intimacy (DeWall & Bushman 2011, 257). Socialization reflects a basic human desire "to form and maintain close, lasting relationships with some other individuals" (DeWall & Bushman 2011, 257). Tools for digitally-mediated, intimate socialization are significant when we seek perceived emotional closeness in spaces where sharing physical presence is not possible. These 'embodied' experiences – where we move with others through screens, interacting in real-time but without the shared material space – have prompted new ways of thinking about what it means to socially connect (Thorpe et al. 2022). Digital interactions offer unique opportunities for connection that may become essential in our increasingly digitally-mediated lives.

Not only is socialization a key aspect of human psychological and physiological needs (DeWall & Bushman 2011), but the human sense of touch also has essential social applications, right from the moment of birth. Studies have shown that licking and stroking of the mother animal is critical to start certain physiological processes in a newborn mammal, indicating "the direct link between skin stimulation and physiological processes" (Van Erp & Toet 2015). From the early need for social touch, it becomes an essential part of daily life: spanning greetings to more intimate communications, social applications of touch have an expansive array of effects based on the nature of the interaction and relationship (Zeagler 2017; Van Erp & Toet 2015). Physical intimacy and social touch have also been shown to positively affect both physical and mental well-being (Hassenzahl et al. 2012). These factors have prompted growing research into how touch and physical intimacy might be mediated through digital technologies, particularly through haptic systems (Raisamo et al. 2022).

This section begins with a primer on haptic technologies, leading into a discussion of mediated social touch explorations and concluding with a review of digital intimacy and social presence literature.

2.1.1 A Haptics Primer

The term haptics originates from the Greek *haptikós*, meaning “able to grasp or perceive” (Jones 2019, 1). It was later formalized by German philosopher and psychologist Max Dessoir to describe the full range of touch-related perception and study (Moussette 2012, 38). Today, haptics refers both to a field of inquiry and to technologies that interface with users through the sense of touch, while haptic communication describes nonverbal, touch-based interaction between people (Moussette 2012, 38). As such, haptics research spans engineering, psychology, and design.

Haptic perception is critical to how people experience and navigate the world, “from providing us with information that allows us to use just the right amount of force to lift a glass of water from a table, to finding the light switch on the bedroom wall in the dark” (Jones 2019, 1). Schneider et al. (2017) describe haptic technology as encompassing two complementary sensory modalities: tactile sensations, perceived through the skin, and proprioception, or the sense of body location and force, including kinaesthetic perception of motion. The skin contains multiple sensory receptors that work together to detect touch, temperature, pain, and itch, forming a full picture of sensation (Jones 2019, 8; Schneider et al. 2017). An important distinction is between tactile and haptic sensing: tactile sensing refers to passive reception of stimuli, while haptic sensing involves active exploration, such as moving the hand to gather information about an object (Jones 2019, 8).

Vibrotactile feedback is the most widely used form of haptic interaction in everyday technologies (Schneider et al. 2017). Vibrotactile displays use actuators (ex. eccentric rotating mass motors) to convert electrical signals into mechanical vibration, typically within a frequency range of 10–500 Hz (Jones 2019, 90). This kind of actuator is widely used due to their low cost, small size, and ease of control, making them frequently used in cell phones, pagers, and game controllers, “where the vibration signal is presented to the whole hand” (Jones 2019, 90).

Despite these advantages, vibrotactile feedback has its limitations. As Raisamo et al. (2022) note, it captures only one dimension of touch and therefore offers limited expressiveness, particularly within applications attempting to simulate interpersonal touch. However, its accessibility and controllability make it a practical entry point for prototyping and experimentation in haptic interaction design.

Camille Moussette defines haptic interaction design as an extension of interaction design that incorporates the human haptic sense, "the same way graphic design relates to visual communication and presentation" (2012, 25). Emphasizing "design for human use," Moussette's concept of "simple haptics" advocates for accessible, exploratory approaches using uncomplicated tools, encouraging designers to "sketch" with haptic feedback and prioritize experiential learning over technical accomplishments (2012, 25). His use of actuation-based descriptors like "bounce," "slide," or "shrink" also suggests alternative ways of conceptualizing haptic interactions beyond purely technical parameters (Moussette 2012, 183).

2.1.2 Mediated Social Touch

Investigating haptics for social touch applications is far from a new concept. Even Facebook once "gambled that future social networks would emulate and replicate face-to-face social interaction, with the possibility of touch interaction enhancing the affective bonds between users" when it purchased Oculus in 2014 (Parisi 2018, 326). Despite this longstanding interest, mediated social touch has yet to see widespread or sustained implementation. Haptics remains a developing research area, and the relationship between media technologies and haptic interaction continues to develop within a field that, as David Parisi notes, "lacks cohesion and stability" (2018, 332). With a growing body of research investigating mediated social touch experiences through haptics (Schneider et al. 2017; Van Erp & Toet 2015; Raisamo et al. 2022), and with digital forms of social interaction becoming increasingly common, this area of haptics research is developing as researchers explore how tactile interaction might support emotional communication across physical distance.

Van Erp and Toet describe the potential of haptic interfaces for social communication, noting that "tactile or kinesthetic interfaces in principle enable haptic communication between people who are physically apart, and may thus provide mediated social touch" (2015, 4). Their research suggests that mediated touch can evoke a wide range of emotional responses, demonstrating "the ability to elicit a wide range of distinct affective feelings" (Van Erp & Toet 2015, 4). These findings have encouraged the development of devices designed to communicate or influence emotional states through tactile feedback. Similarly, Raisamo et al. report that mediated social touch can modulate physiological responses, increase trust and affection, help establish interpersonal bonds, and encourage pro-social behaviour (2022). Together, these studies highlight the potential of mediated touch to support emotional and relational communication when physical proximity is not possible.

A related exploration of mediated touch appears in Holly Thorpe and their co-authors' article "We seek those moments of togetherness: Digital Intimacies, virtual touch and becoming community in pandemic times." Drawing on feminist materialist and posthumanist theory, Thorpe et al. examine how digital technologies shaped experiences of closeness and community during COVID-19 pandemic lockdowns. Their research considers the "more-than-human" relationships between bodies, technologies, and environments that produce feelings of connection in online sport and fitness classes (Thorpe et al. 2022)

Thorpe et al. explore haptics through digitally mediated bodily presence. Participants of the study described experiencing a sense of closeness through parallel movement with others in virtual fitness sessions. As Thorpe et al. explain, "through these shared experiences, they were in close proximity to other bodies," producing familiar embodied encounters even within digital environments (2022). In this context, virtual touch emerged through synchronized movement as well as through the effort of intentionally reaching out to others online.

In contrast to these embodied but non-tactile forms of mediated social touch, many haptics explorations have focused directly on producing tactile sensation for social touch. Several commercial and research prototypes have embedded vibrotactile feedback into artifacts such as jewelry or wearable devices, allowing couples to exchange signals and maintain a sense of connection across distance (Hassenzahl et al. 2012). However, many mediated social touch systems focus on intimate one-to-one communication, particularly within romantic relationships. There is little to no evidence of tactile systems implemented for broader social interaction or designed for communication within social groups – see **Related Works** for a review of the few existing explorations in this area.

Many applications of mediated social touch emphasize shared virtual presence and visual stimulation rather than tactile sensation alone (Raisamo et al. 2022). Collaborative virtual environments used in contexts such as education, therapy, or fitness often attempt to increase feelings of social presence by situating users within the same digital space (Thorpe et al. 2022; Van Erp & Toet 2015). While these approaches demonstrate how embodied participation in digital environments can support feelings of connection, they do not necessarily incorporate direct tactile feedback.

2.1.3 Digital Intimacy and Social Presence

Traditionally, intimacy is closely associated with physical touch, often linked to sexuality and kinship (Sadowski 2016, 43). We typically think of intimacy in terms of physical presence, but this concept can also apply to digital intimacy. Helga Sadowski suggests that intimacy is dependent on mutuality, writing that it "can never be a one-way street, even when the other might not be geographically close" (2016, 45). Intimacy, even digitally, is built by mutual sharing, mutual knowledge, and putting in effort on both sides.

Digital communication is now embedded in everyday life and no longer tied to stationary computers. As Sadowski observes, digital devices often accompany intimate moments of daily life: "laptops are taken to bed, mobile phones are held close to the heart when a right-handed person is swiping through profiles on Tinder, [and] sweaty streaks on the tablet testify to states of being really in touch with the touchscreen" (2016, 16). These technologies have become familiar companions in everyday routines. Lindsay Balfour et al. similarly describe how devices increasingly "interact with us to send us to sleep, wake us up, and maintain human-human relationships" (2025, 71). As these technologies become embedded in everyday practices of communication, our understanding of intimacy has begun to shift. As Sherry Turkle writes, "as we instant-message, e-mail, text, and Twitter, technology redraws the boundaries between intimacy and solitude" (2017, 13).

For Sadowski, intimacy is therefore "better understood as extremely mobile processes of attachment" (2016, 63). Social and geographical boundaries shift through the frames of our devices, affecting our understanding of space. Balfour et al. suggest that for a digital environment to transform from abstract space into a place, it requires meaning: "Space plus connectedness equals place" (Balfour et al. 2025, 80). In this sense, connection is what causes digital environments to feel inhabited rather than distant. Feelings of social presence therefore become central to digital intimacy, as they allow individuals to sense another person on the other side of a mediated interaction, no matter how far away physically they might be.

Oh, Bailenson, and Welch define social presence, or co-presence, as the "sense of being with another" which requires a "co-present entity that appears to be sentient" (2018). The concept was initially developed to understand how people interact across different forms of media, particularly within virtual environments (Oh et al. 2018). In their systematic review, Oh et al. identify intimacy and immediacy as the two core components of social presence, arguing that without this sense of presence "the mediated other is merely experienced as an artificial entity and not a social being" (2018). Similarly, Marc Hassenzahl emphasizes that social presence often relies on simultaneity, noting that "an important requirement for physicalness is simultaneity… both users need to contribute to the experience in a synchronous way" (2012). In this way, digital intimacy relies not only on communication technologies themselves, but on the extent to which those technologies enable participants to feel present with one another through interaction. Feeling present with another is not reliant on geographical bounds but on emotional connection and relation.

Feelings of social presence can also be enhanced through the introduction of interpersonal touch. Oh, Bailenson, and Welch's review "found a positive relationship between haptic feedback and perceptions of social presence" (2018). Research further suggests that mediated social touch can "modulate physiological responses, increase trust and affection, help establish bonds between humans, and initiate pro-social behavior" and that "in its simplest form, haptic stimulation can be used to create an illusion of physical co-presence" (Raisamo et al., 2022). Incorporating tactile feedback into digital interactions can thus support the sense of social presence within virtual spaces.

2.2 Patterns

Beyond emotionally expressive touch, tactile feedback can serve as a form of communication through patterns. In the context of this study, a pattern is defined as an arrangement of elements in a linear sequence (Alexander 1977, xvii). Similar to spoken and written language, meaning can emerge from recognizable sequences and shared conventions. Translating haptic feedback into a communicative system, however, is not always straightforward.

To explore how meaning can arise from haptic signals, examples from auditory and tactile patterns are reviewed, including their use in encoding information across distance. The section concludes with a review of how assistive technologies have utilized haptics to develop communication systems.

2.2.1 Audible and Tactile Pattern-Based Communication Systems

A central pillar of both this project and pattern-based communication as a field of research, is to understand how a pattern becomes a recognizable communication system or language between humans. One approach is to translate an existing spoken language into patterned signals. The first chapter of James Gleick's *The Information*, "Drums That Talk," compiles a history of communicating information across distance. Gleick describes African drum languages as long-distance communication systems that translate the tonal patterns of spoken words into drumbeats of varying pitch, which could be heard for miles (Gleick 2011, 28).

In many African languages, tonal variation is essential for distinguishing meaning between words (Gleick 2011, 26). John F. Carrington, one of the missionaries cited in Gleick's book, observed that the drums conveyed not only announcements and warnings but also prayers, poetry, and even jokes (Gleick 2011, 26). To communicate full phrases or multiple sentences using tone alone, drum patterns often incorporated additional beats that provided contextual clarification. As Gleick writes, "Listeners are hearing only staccato drum tones, low and high, but in effect they 'hear' the missing consonants and vowels, too" (Gleick 2011, 28). As an example, the *Atumpan*, a talking drum central to Akan culture in Ghana, consists of a pair of drums which produce two distinct pitches; "one emits a high-pitched sound, while the other resonates with a lower pitch" (Asare 2025). Walter J. Ong describes these talking drums as "probably the most highly developed acoustic speech surrogates known around the world" (Ong 1977, 411).

Gleick connects these drum languages to the development of Morse code in the nineteenth century, another form of what he describes as a "percussive code" (Gleick 2011, 23). Morse code operates as a coded alphabet that translates letters of the written English language into sequences of short and long electromagnetic pulses on a telegraph – dashes and dots. Developed by Samuel F. B. Morse and Alfred Vail, the code requires a double translation process: "language to signs, mind to fingers" (Gleick 2011, 24). The written alphabet functions as an intermediate symbolic layer between speech and code; pulses are translated into letters, which form words representing spoken language (Gleick 2011, 25). While African drum languages translate tonal qualities of speech into rhythmic patterns of pitch, Morse code translates written symbols into rhythmic electrical pulses. Both systems demonstrate how patterned signals have been developed to transmit detailed information across distance using sound alone.

Beyond audible systems, numerous historical examples exist for how patterns have been used as tactile or visual communication methods. One such example is the "tangible telegraph," an alternative technique for receiving messages through the Morse electric telegraph system (Parisi 2018, 168). Rather than hearing the dots and dashes, the tangible telegraph involved operators either directly feeling the electric shocks of varying duration or by placing their hand on the telegraph's striker mechanism to perceive the rhythmic pattern physically (Parisi 2018, 169).

Another example is the use of Australian message sticks, tactile and visual communication devices used by Indigenous Australian communities. These carved wooden objects contained graphic markings that encoded messages and facilitated communication across long distances (Kelly et al. 2024). Message sticks were used across approximately 440 language groups and represent "the widest geographic and linguistic range of any graphic code in the world, after writing" (Kelly et al. 2024).

A further example is Braille, a tactile reading and writing system developed in the nineteenth century by Louis Braille for blind and visually impaired individuals. Braille is read by scanning raised dot patterns arranged within a grid cell structure, with each cell pattern representing a letter in the Braille alphabet (Parisi 2018, 165). Like Morse code, Braille translates written language into a different sensory modality, allowing language to be communicated through touch.

Together, these examples demonstrate the methods in which patterned signals can become a communication system. Meaning emerges from shared conventions and collective understanding – in these cases, to associate specific patterns with letters, words, tones, or messages.

2.2.2 Haptic Communication in Assistive Technologies

Historically, researchers have explored haptic communication as an alternative to the typical audio and visual channels, if they are "unavailable due to impairment or occupied by other stimuli" (Dunkelberger et al. 2018, 25). As a result, assistive technology research has played a significant role in developing tactile communication systems that encode information through haptic feedback. The systems reviewed offer valuable insight into how tactile signals can become structured communication tools.

For instance, Morse code and Braille have been adapted into haptic interfaces for digital communication (Tan et al. 1997; Jayant et al. 2010). Both of these methods are based on letters as the building blocks of language, but communicating each letter can take a long time when used for conversational interaction. To address this limitation, some researchers have explored using phonemes (distinct units of sound that distinguish one word from another) rather than letters as the fundamental units of haptic communication (Israr et al. 2009; Dunkelberger et al. 2018). Because phonemes represent sound units rather than individual letters, they can allow for faster information transfer.

One example is the MISSIVE system (Dunkelberger et al. 2018), which encodes the 40-part English phoneme set through brief multi-sensory haptic cues. The MISSIVE communication system is a compact wearable device, designed to be worn as a band on the upper arm. It is made up of a vibration component, a lateral skin stretch component, and a radial squeeze component, with all three components used to create each phoneme cue (Dunkelberger et al. 2018, 27). By encoding phonemes rather than letters, this system enables fast-paced haptic communication through tactile signals.

Another example of an on-body tactile communication system is the TapTap haptic wearable prototype. TapTap was designed to support blind and low-vision (BLV) music learners by enabling teacher-student pairs to exchange real-time haptic signals during music instruction (Lu et al. 2025). When the teacher tapped their heels together, vibrotactile feedback was emitted on the student's paired device. The system allowed two-way communication and provided two vibration intensities: moderate and strong (Lu et al. 2025).

Importantly, the meaning of the vibrations was not predetermined by the TapTap system itself. Instead, participants of Lu's study were invited to develop their own interpretations based on timing, context, and pre-agreed codes (Lu et al. 2025). Examples included nudging for attention, binary commands such as "faster" or "slower" (an example was "faster" being a more intense vibration and "slower" being softer), and signals intended to communicate the feeling of musical rhythm. Some participants of Lu's study reported that vibration signals only made sense if students and teachers discussed what it meant beforehand (Lu et al. 2025).

The MISSIVE communication system and the TapTap prototype are examples of assistive technologies which, alongside previously discussed mediated social touch devices, sample the broad scope of approaches to haptic communication design. Many existing systems either attempt to recreate gestures of social touch (Schneider et al. 2017; Van Erp & Toet 2015; Raisamo et al. 2022) or translate spoken or written language into tactile signals (Dunkelberger et al. 2018; Tan et al. 1997; Jayant et al. 2010). These examples demonstrate how a pattern, nonverbal cue, or vibration can be imbued with communicative meaning. At the same time, they suggest opportunities to explore alternative methods of meaning-making within social haptic communication research.

2.3 Objects

2.3.1 Evocative Objects for Relatedness

Sherry Turkle's book *Evocative Objects: Things We Think With* asks what "it" is that makes an object evocative: "where does it take you; what do you feel; what are you able to understand?" (Turkle 2007, 7). In this framing, objects become meaningful not only because of their material form but because of the experiences and memories attached to them. Turkle suggests that many objects "exert their holding power because of the particular moment and circumstance in which they come into the author's life" (2007, 8). Through this connection between object and lived experience, everyday artifacts can evoke memories and emotional responses long after the original moment has passed.

Marc Hassenzahl et al.'s 2012 article "All You Need Is Love" reviews artifacts that are designed to help with relatedness over distance, specifically focusing on couples in romantic relationships. In this context, "relatedness" refers to the feeling of emotional connection to another person (2012). Hassenzahl et al. identify six strategies used by designers and researchers to create relatedness experiences: awareness, expressivity, physicalness, gift giving, joint action, and memories (2012). Their work argues that the "fulfillment of psychological needs, such as relatedness, is at the heart of positive experiences with technology and other artifacts" (Hassenzahl et al. 2012). Personal artifacts such as wedding rings, pictures, or clothing can evoke these feelings by reminding users of a relationship and the person associated with it. In this sense, objects become carriers of memory, enabling individuals to maintain a sense of awareness and connection with others through shared experiences.

Turkle offers an example of objects as carriers of connection in the testimony of a sculptor's widow describing her husband's collection of scholars' rocks. Reflecting on the relationship between the objects and her late partner, Turkle asks: "How can a rock be a man?" (2007, 319). The question highlights how objects can come to represent a person through memory and association. By embedding personal meaning into an artifact, the object becomes evocative of both a past experience and the individual connected to it. Together, Hassenzahl's design strategies for relatedness and Turkle's accounts of evocative objects demonstrate how artifacts can evoke memories that produce a sense of closeness to people. The connection between object and emotion is often explainable, especially when considering the strategies examined by Hassenzahl: there are clear motivating factors that drive affective objects.

2.3.2 Worry Stones and Affective Sensory Objects

A worry stone refers both to a type of carved stone and more broadly to any smooth, stone-like object rubbed between the fingers as a calming gesture. Despite their widespread cultural presence, worry stones have received limited academic attention regarding their emotional or therapeutic benefits. While sensory and fidget toys have been studied more extensively in psychology and education research (ex. Liu 2025; Kriescher 2020), relatively little work examines the historical use or affective qualities of worry stones themselves.

In 2017, there was a clinical trial proposed by Michael Otto which included worry stones as part of a broader investigation into how physical activity during therapy sessions might support emotional processing. The study explored whether small physical actions during therapy could help participants better cope with emotionally difficult topics. Worry stones were proposed as one possible intervention for supporting participants' comfort while discussing intense emotions. The study ultimately did not come to fruition due to a lack of therapists able to participate.

On fidget and sensory toys in general, there is conflicting research on whether or not there is a measurable effect on focus (Kriescher 2020), particularly across the wide age range of participants studied in recent years. However, tactile objects have a long history of use as tools for repetitive, sensory engagement. From the worry stones and worry beads associated with ancient Greek practices to contemporary fidget toys and puzzles such as the Rubik's Cube, tactile interaction with small handheld objects has persisted as a way to occupy the hands and regulate attention (Liu 2025, 1). Yuqi Liu's 2025 article "The Rise of Sensory Fidget Toys" argues that simple, repetitive tactile input can provide stress relief by distracting from anxious thoughts and helping users focus on the present moment (Liu 2025, 3).

Returning to Hassenzahl's discussion of objects which evoke feelings of relatedness, the calming qualities of tactile objects such as worry stones suggest another layer to evocative artifacts. Through repeated tactile interaction, these objects may become associated with particular emotional states or moments of reflection. The physical sensation of rubbing the object can itself evoke feelings of calm or grounding (Liu 2025, 3). In this way, sensory objects may function similarly to evocative artifacts by linking a physical object to emotional memory and embodied experience. One consideration of this research study is whether tactile objects that evoke calm might also support feelings of interpersonal connection when used within shared or communicative contexts.

2.4 Conclusion

The literature reviewed provides context for understanding how tactile technologies and objects can support socially meaningful communication experiences. Rather than replacing human touch, this research explores how haptics can extend its affective qualities, supporting intimacy and social presence through digital mediation. Insights from studies on mediated touch, pattern-based communication, and haptic technologies inform the design of Touchstones. Vibrotactile feedback, paired with a worry stone-like form, provides the material and interactive foundation for prototyping to explore group-based haptic communication.

CHAPTER 3: RELATED WORKS

This review examines relevant social haptic experiences to contextualize this project. The related works review is broken into two core sections: haptic communication projects, a mix of commercial and design project examples of physical devices for communicating via haptics; and haptic design tools, hardware and software used to design and develop haptics. The selected works do not represent a comprehensive scan of the field, but rather a collection of the current, relevant, and intersectional work which informs the project.

3.1 Social Haptic Devices

Haptic technologies have long been explored as a means of facilitating social connection and presence at a distance (see **Literature Review**). Interest in this area has grown in recent years, particularly in response to increased reliance on digitally mediated communication (Zhang et al. 2024; Banerjee et al. 2025; Thorpe et al. 2022). This section focuses on physical haptic devices designed for interpersonal communication.

3.1.1 Hug Shirt

DESIGN PROJECT & COMMERCIAL PRODUCT

Figure 2: CuteCircuit's most recent iteration of the Hug Shirt, demonstrated by two people wearing the shirt and hugging. From CuteCircuit, retrieved February 2026, https://cutecircuit.com/hugshirt/.

CuteCircuit's Hug Shirt was first developed in 2002, but has been iterated upon over the years and become more and more advanced. It's now a product that is currently available for purchase (see Figure 2). The Hug Shirt is able to "send hugs over distance," achieved through embedded sensors and actuators (Rosella & Genz, 2024). The sensors capture the strength, location, and duration of touch, then actuators recreate the "touch and the emotion of a hug" to another Hug Shirt (Rosella & Genz, 2024). The shirt was first designed with test subjects to analyse "what it means to be hugged" and to inform the careful selection of fabrics which were associated with the warmth of a hug (Pailes-Friedman 2016, 119). This project is unique in terms of its ability to map and recreate exact touch locations.

The shirt requires a corresponding mobile app for sensor data communication over WiFi. Users are also able to send "hugs" with only the app (without needing to also own the shirt) if they know their loved one has the shirt. The shirts also possess the ability to send the same hug to multiple people at once, like a broadcast, so long as everyone has the app open at the same time (see Figure 3). The shirt itself is a long-sleeve made of soft, stretchable, digitally printed fabric, which visually highlights the actuation areas (Rosella & Genz, 2024).

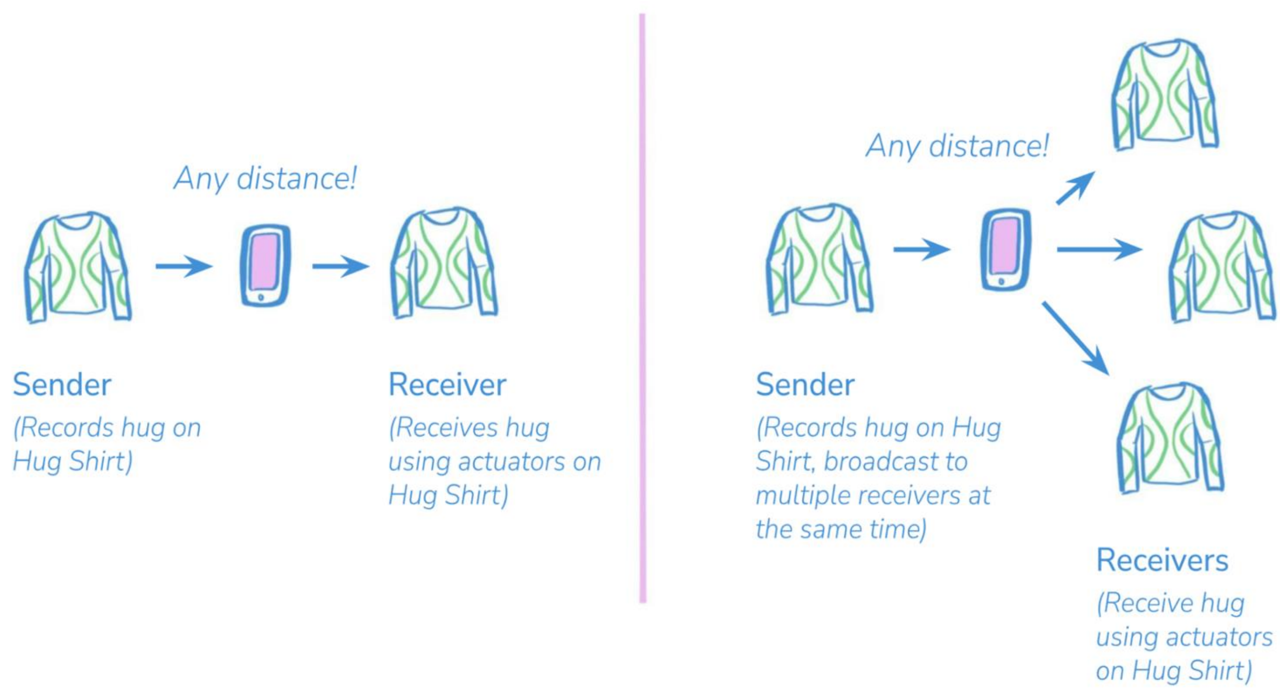

Figure 3: The Hug Shirt interaction scenarios. Sketch by author.

3.1.2 Nudgeables

DESIGN PROJECT

Figure 4: *Nudgeables example pair. Image courtesy of Social Body Lab.*

“Nudgeables” (Figure 4) from OCAD’s Social Body Lab (2013) is a modular hardware kit developed for use in creating paired sets of wireless wearable communication devices (Hartman 87, 2025). Users are given a “Nudger” and “Notifier” to create wearables – such as clothing, accessories, or jewellery – to enable communication via nudging the paired device from across a room. The use case of this project is to communicate codes to “friends, partners, or colleagues while in the company of a larger group of people” (Hartman 87, 2025). It works exclusively one-to-one through radio transceivers, which also limits distance to transmitting signals between devices only within a room. It works independently to communicate between devices, as it utilizes radio rather than through a connection to a mobile device. It is limited to a single buzz, a discrete “tap” with open-ended meaning and wearability, to be determined between the user pair.

In this project, the distance limitation and single “tap” were a part of the intent, but I see an opportunity to extend the core ideas into open-ended play. I am most interested in the flexible wearability of the Nudgeable: users can take the functionality into the design of an object which suits the relationship of who they are paired to and their personal preferences. In Figure 5, I sketched an example scenario of a Nudger embedded in a tie and a Notifier in a headband. Building on this, *Touchstones* expands the flexibility of play into a shared making experience and collaboratively developing a meaning for a "nudge" between the pair who own them. Additionally, expands by moving beyond pairs and allowing for group communications.

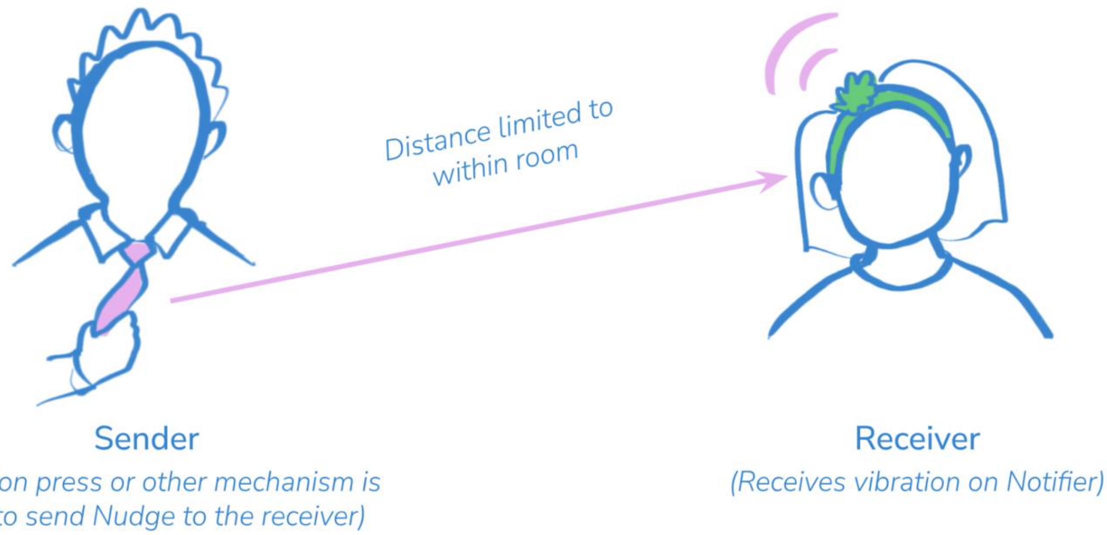

Figure 5: Example Nudgeables interaction scenario. Sketch by author.

3.1.3 Bond Touch Devices

COMMERCIAL PRODUCT

Figure 6: Bond Touch 4 bracelet pair. Retrieved February 2026, https://bond-touch.com/en-ca/products/bond-touch-4-long-distance-bracelet.

A current example that expands on some of the technical aspects of *Nudgeables* is Bond Touch, a company founded in 2017 and best known for its paired bracelets designed for long-distance couples (see Figure 6). Similar products exist, such as FeelHey ("Hey Bracelets Pair") and Totwoo ("Smart Bracelets"), which currently offer bracelets for the same purpose and similar functionality, but Bond Touch has a wide online presence and boasts having "helped over one million people to connect with their loved ones" (Bond Touch, 2025). Their product ecosystem includes the Bond Touch 4 bracelet, Bond Lite (an Apple Watch app), and the Bond Heart necklace, which transmits recorded heartbeats as vibrations.

The Bond Touch 4 bracelet is the closest existing device to Touchstones known. It allows one-to-one touch communications with up to three paired contacts, managed through a corresponding mobile app (see Figure 7). The app sets pairings, controls recipients, provides a replay feature for missed touches, and allows colour-coded indicators for each connection. Touch patterns are sent when the bracelet is tapped, using WiFi through the paired mobile device, enabling distanced communication.

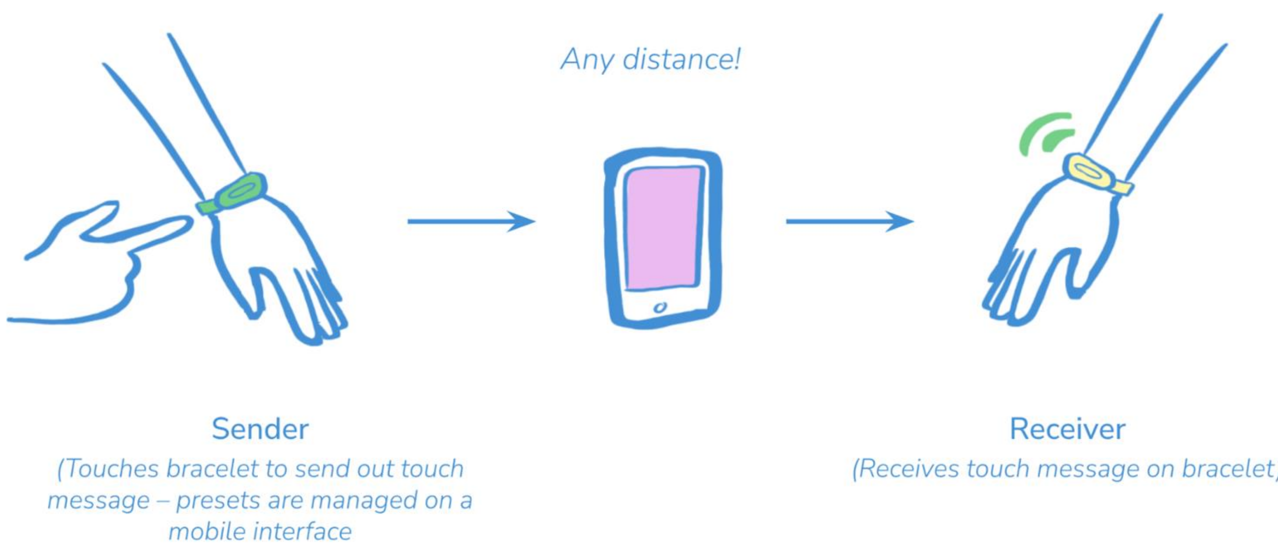

Figure 7: The Bond Touch 4 interaction scenario. Sketch by author.

Their Bond Touch Lite application for the Apple Watch works very similarly to the bracelet. Users can open the application and tap out patterns to be output on the paired device (see Figure 8). However, in the Lite version, users can only connect to a single person.

Figure 8: Bond Touch Lite smartwatch application. Retrieved February 2026, https://bond-touch.com/en-ca/collections/bond-touch-lite.

Unlike Nudgeables, Bond Touch devices are worn only on the wrist. Additionally, while the app allows users to attach meanings to touch patterns, it provides no guidance on creating shared meaning, and the bracelets offer only limited vibration intensity and style variation. These constraints suggest opportunities for expansion through more personalized wearability, as well as interfaces that support collaborative pattern creation beyond one-to-one communication.

3.1.4 Summary

Across the devices discussed, key themes relevant to this project include group haptic communication, playful wearability, and the facilitation of meaningful interaction. In this context, meaningful interaction refers to haptic experiences that convey social presence and a sense of closeness between users. These works are considered in terms of how their forms, interaction models, and communication networks inform the design direction of this research.

For instance, Nudgeables demonstrate the potential of flexible wearable forms to support personalized, playful interactions, while devices such as Bond Touch and the Hug Shirt show how haptic feedback can be used to express intimacy and reinforce emotional connection. These examples provide reference points for designing tactile communication to support emotional connection and the perception of closeness.

However, group communication is limited in existing works. The systems reviewed support one-to-many broadcasting (ex., Hug Shirt) or one-to-one channels with multiple people in parallel (ex. Bond Touch), rather than fully networked, many-to-many communication. Designing non-verbal, tactile interaction for groups introduces additional challenges, including sender identification, message targeting, and shared interpretation. As a result, friend circles, family units, or other groupings who may use text-based communications like group chats are underrepresented in haptic communication research. Table 1 overviews the social haptic devices discussed, including the limitations of communication networks and the mode of interaction.

Device Name	Sender(s) and Receiver(s)	Device Type
Hug Shirt	One-to-many, one-to-one	Wearable Device
Nudgeables	One-to-one	Wearable Toolkit
Bond Touch 4	One-to-one (but multiple one-to-one communication channels possible)	Wearable Device
Bond Touch Lite	One-to-one	Wearable Device
Touchstones	One-to-many, one-to-one	Holdable / handheld

Table 1: Summary of reviewed social haptic devices.

3.2 Haptic Design Tools

While the previous section examined physical devices in social contexts, this section reviews software and hardware tools for designing haptic experiences. Approaches to haptic design vary by application, but a range of platforms, both commercially available and experimental prototypes, have emerged to support prototyping and development (Rothammer & Müller, 2025; Ghost, n.d.; RichTap, n.d.). This section surveys a selection of these tools.

3.2.1 Hapticlabs

COMMERCIAL PRODUCT

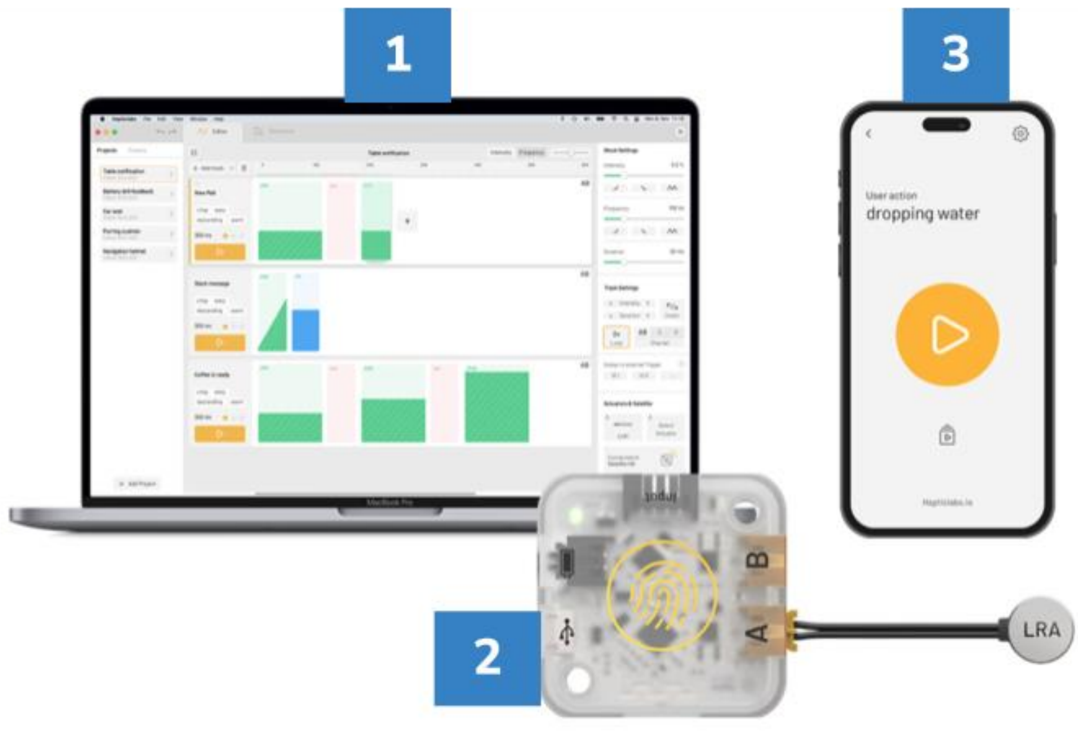

Figure 9: The Hapticlabs system: 1. Hapticlabs Studio, 2. DevKit, and 3. Hapticlabs Mobile. Adapted from Hapticlabs, retrieved February 2026, https://www.hapticlabs.io/.

Hapticlabs, founded in 2021 by Thomas Müller and Michael Rothammer, is a no-code toolkit that supports haptic design across contexts such as virtual reality, healthcare, games, and apps (Rothammer & Müller, n.d.). Its suite includes three components, as seen through the annotations in Figure 9: 1. Hapticlabs Studio (software), 2. DevKit (hardware), and 3. Hapticlabs Mobile (mobile testing).

Hapticlabs Studio (1) is a desktop visual editor for designing haptic feedback using "blocks" of vibration, pause, and pulse arranged into tracks. The interface includes drag-and-drop functionality, waveform editing, and adjustable parameters such as intensity, duration, and frequency, alongside real-time playback for iteration.

The DevKit (2) enables physical prototyping by allowing patterns created in Studio to be tested through hardware components, including multiple actuators and input sensors. The actuators included are an eccentric rotating mass (ERM) motor, a linear rotating actuator (LRA), and a VoiceCoil motor from Titan Haptics (Rothammer & Müller, n.d.). Hapticlabs Mobile (3) extends this system by enabling quick haptic pattern prototyping on mobile devices.

As a suite, Hapticlabs is representative of broader industry platforms such as Ghost and RichTap, which similarly offer waveform-based design (“Ghost”, n.d.; “RichTap”, n.d.). These tools are intentionally general-purpose and do not focus on communication or meaning-making from haptics. In contrast, this research is concerned with how haptic patterns function as communicative expressions. However, aspects of these platforms, particularly their visual interfaces, inform the development of this project’s GUI and suggest approaches for introducing users to haptic pattern creation.

3.2.2 CollabJam

DESIGN & RESEARCH PROJECT

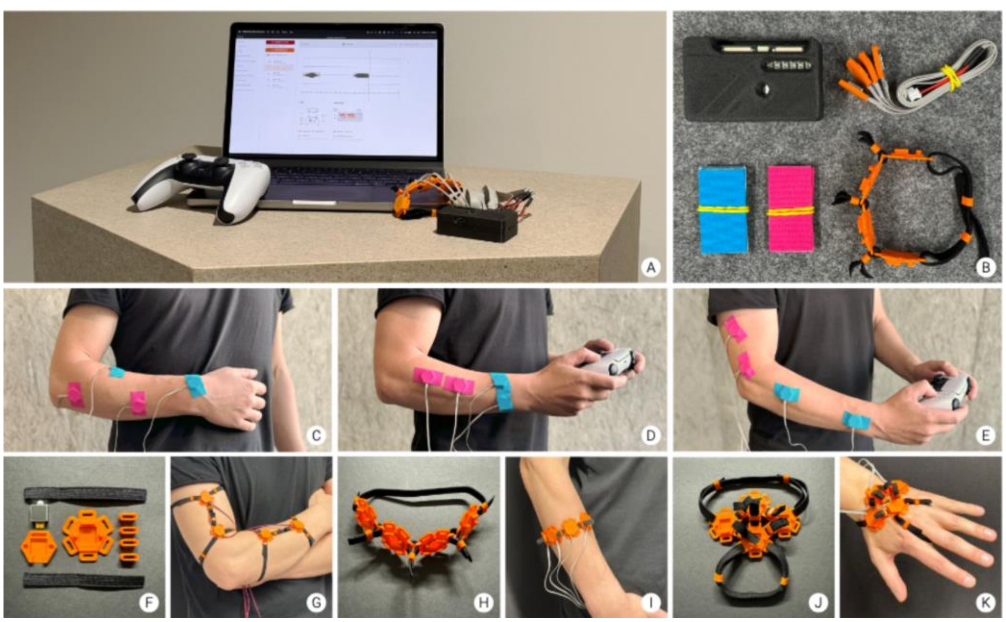

***Figure 10**: CollabJam consists of a software application, a tactile display, and a keyboard or gamepad to control the actuation. From Dennis Wittchen et al., “CollabJam: Studying Collaborative Haptic Experience Design for On-Body Vibrotactile Patterns,”* CHI ’25: Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems, *licensed under CC BY 4.0. doi: 10.1145/3706598.3713469*

CollabJam is a “prototyping suite for collaborative vibrotactile experience design” (Wittchen et al., 2025). The suite consists of a software application, a tactile display (made up of LRA motors and harness attachments), and a keyboard or gamepad to control the actuation. Users can connect to virtual “rooms” to feel synchronous vibrations, with the ability to mute others if needed (Wittchen et al., 2025). These spaces are used to collaboratively design vibrotactile patterns, which is achieved through pressing buttons on a keyboard or game-pad. Users are able to work in the same physical space on separate devices or fully remotely – either way, they can freely place actuators on their bodies with harnesses and kinesio tape to feel feedback while creating sequences. As seen in Figure 10, the orange objects are harnesses and the blue and pink tabs are the kinesio tape. Using the buttons on the game controller, sequences can be recorded for playback and users can edit their patterns using visual representations (waveforms) or by “overdubbing new tactile inputs” (Wittchen et al., 2025).

This prototyping tool explores the benefits of co-design in haptic experience design processes and finds success in allowing multiple users to sketch, prototype, and share felt experiences. CollabJam also moves beyond “desktop interfaces,” with the paper noting that “most tools for vibrotactile pattern design are built on desktop interfaces, enabling designers to control parameters via sliders, response curves, and other casual widgets” (Wittchen et al., 2025). Similar to how Hapticlabs offers a hardware DevKit to prototype outside of a solely screen-based interface, CollabJam’s adds tactile buttons and actuators for feedback. The co-creation process and physicality of CollabJam serve as useful inspiration for my prototyping process and offer insight to current topics in haptic experience design.

3.2.3 Shape-Kit

DESIGN & RESEARCH PROJECT

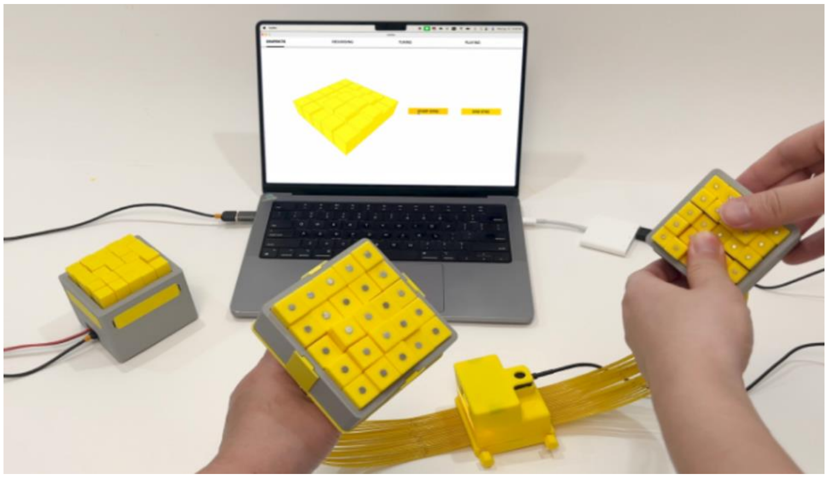

Figure 11: Shape-Kit's GUI, tracking module, and programmable shape display. From Ran Zhou, et al., "Shape-Kit: A Design Toolkit for Crafting On-Body Expressive Haptics," CHI '25: Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems, *licensed under CC BY-NC-SA 4.0. doi: 10.1145/3706599.3721280*

Shape-Kit is an example similar to CollabJam in that it uses physical prototyping components to design haptics. However, Shape-Kit focuses itself on exploratory, on-body, crafted haptic experiences, while CollabJam focuses on co-designing haptic experiences. Shape-Kit (see Figure 11) is a modular, open-source toolkit which involves an "analog, manually actuated pin-based shape display format" and a GUI for real-time visualization of patterns (Zhou et al., 2025). There are multiple modules of different pin display scales, intended for use on different areas of the body – for example, the smallest is suggested to be placed on a finger or cheek. These modules are the actuators, so rather than the vibration motors in other related works covered, the pins are motorized to move up and down upon skin. The haptic patterns relayed through the grid system come from one user exploring various tactile inputs and materials on the modules, then the modules relaying that felt experience (such as the pressure, texture, and location) through the pins on a receiving user. This toolkit is designed to encourage the exploration of touch across the body to enhance the design process for haptic interactions.

The ability and encouragement to play with the felt on-body experience of the haptics to aid in the design process is the aspect most of interest in Shape-Kit. CollabJam does also encourage open-ended experimentation with actuator placement, but Shape-Kit's research concluded that its "embodied and tactile nature not only fostered this bodily exploration but also allowed ideas to emerge in ways that would be challenging in conventional brainstorming settings" (Zhou et al., 2025). Sensorial exploration and collaboration, which came from participants in the same room playing with materials and textures to send each other, are the most applicable aspects of this research to my own. The body-focused approach to designing haptics for felt experience supported users in iterating their patterns through their emotional responses to the various gestures and materials. When working with complex, non-verbal interactions with touch, the success of collaboration and physical exploration in both CollabJam and Shape-Kit is useful context for guidance.

3.2.4 Summary

Table 2 provides a summarizing comparison of the haptic design tools discussed. The table highlights each tool's type of tool and approach.

Haptic Design Tool	Type	Approach
Hapticlabs	Commercial, no-code toolkit	Drag-and-drop pattern editor, waveform editing, includes desktop GUI, mobile GUI, and DevKit hardware
CollabJam	Research prototype	Keypad-based haptic design and collaborative pattern creation, embodied iteration process
Shape-Kit	Research prototype	Physical, manipulable building blocks for haptic pattern creation

Table 2: Summary of reviewed haptic design tools.

3.3 Conclusion

Between the devices and prototyping suites, the examples reviewed provide the contextual background of work that exists within the same sphere as my own. There are few examples of haptic communication devices that allow for wearability beyond a single function and few which explore communication beyond one-to-one connection. The aspects of playful, flexible on-body interactions and enabling group interaction beyond simple broadcast (as seen in the Hug Shirt), highlights the gap identified through the related works.

On the design tools side, research prototypes demonstrate the value of treating pattern-making as an embodied, iterative process. Systems such as CollabJam and Shape-Kit show how designing through physical gestures and bodily feedback can produce more expressive and nuanced haptic experiences than parameter-based approaches alone (Wittchen et al., 2025; Zhou et al., 2025). While commercial platforms like Hapticlabs remain largely screen-based, they similarly acknowledge the importance of testing haptics through physical output with their DevKit.

Together, these works point to the importance of designing haptic communication through felt experience and iterative refinement. As responses to touch are highly subjective and shaped by interpersonal context, the gaps identified through the related works suggest a need for haptic design systems that support personalization and experimentation. *Touchstones* addresses the limited exploration of group social haptic experiences and builds upon approaches of embodied, iterative design for the development of shared meanings between users.

CHAPTER 4: METHODS & METHODOLOGIES

4.1 Research Through Design

Coming from a graphic design background, my typical design process follows an iterative cycle: a spark of an idea leading to initial exploration, secondary research, sketching for ideation, prototyping, and refinement through testing and analysis. However, this project centres on designing for and with others. Iteration still plays a central role, but the input of participants and collaborators is important to the nature of the study and fundamentally shapes each phase.

The core methodological approach of this research study is Research Through Design (RtD). Frayling first characterized research *through* design as one type of design research in 1993, defining the other forms of design research as research *about* design and research *for* design (Zimmerman et al., 2010). In the context of this project, RtD offers a scaffold for extending my personal design process into design research. An iterative prototyping approach as a design research activity is utilized in this study: “making as a method of inquiry” offers valuable contributions in the creation of artifacts (Zimmerman et al., 2007). The artifacts produced are not presented as definitive solutions but as research outputs that generate knowledge through their construction and user interaction (Zimmerman et al., 2007; 2010).

This study is also informed by Sengers et al.’s concept of Reflective Design, which argues that “ongoing reflection by both users and designers is a crucial element of a socially responsible technology design practice” (Sengers et al., 2005). Evaluation of each prototype occurred on two levels: feedback from sharing and designer reflection. Observing how users interacted with the interface (Bastien, 2010), from participants in the workshops and visitors of the prototypes in class exhibitions, provided insight into confusion points and interaction strategies not accessible through self-evaluation alone. At the same time, my own reflective documentation formed an essential component of evaluation. The strengths of prototypes were therefore assessed not only through usability considerations such as accuracy of the GUI and comfortability of the physical device, but also through how effectively each prototype functioned as a communicative probe (Sengers et al., 2005).

4.2 Workshops

This project's approach to creating tools for tactile communication acknowledges that the prototypes are not only for my own use. As a result, feedback is gathered though both informal sharing and explorative workshop sessions. At each stage of the iterative prototype development, I received informal feedback through class exhibitions and peer suggestions which informed the following iteration. Formal participants were only invited into the process to inform the final prototype. While participants contributed insights into group-based haptic communication and provided feedback on Prototype 4, they were not involved in the complete design of the final system nor were participants included throughout every design phase.

With the workshops in this study being single sessions where each group of participants were invited to participate once, describing this design research activity as exploratory, participatory, and generative workshop sessions is appropriate. The workshop design is informed by generative design approaches described in Sanders & Stappers book, *Convivial Toolbox*, which emphasize the use of "make" toolkits to facilitate creative expression. This approach "involve[s] participants by having them perform a creative act with respect to the subject under study" while also inviting direct reflection on their experiences (Sanders & Stappers 2016, 69). A "make" toolkit is an open-ended term for study-specific tools which "help people generate artifacts" to access tacit knowledge – for the workshops, these artifacts included the creation of brainstorming sketches and waveform patterns (Sanders & Stappers 2016, 70).

This approach informed both the structure and tools used in the workshops. The workshops create a shared experience in an existing friend group where vibrotactile haptics are used for the group to collaborate on a personalized, meaningful vibration pattern. The "make" toolkit included the sharing of pre-defined vibration patterns as recognizable starting points for participants, as well as the waveform drawing tool GUI and Touchstones as an open-ended system for creating new patterns. These tools encouraged participants to collaboratively design a pattern and assign meaning to vibrations based on their own experiences.

Additionally, the workshop format utilized group dynamics as a generative resource. As described by Sanders and Stappers, "when people come together, the number of ideas and the breadth of the ideas that are brought to the table increase dramatically" (2016, 58). The workshops invited pre-existing friend groups and the flow of conversation and diversity of perspectives contributed to a wider range of ideas and interpretations, supporting the collaborative development of shared haptic meanings.

The workshop structure was also informed by Reflective Design (Sengers et al., 2005), incorporating play and familiarity to support engagement. Vibrotactile communication was introduced through a “tapas”-style metaphor, framing vibrations as small tastings and patterns shareable experiences to prompt exploration and discussion.

Specific details of the workshop facilitation can be found in the **Haptics Tapas Workshop** chapter of this document. The data analysis process involves the reading and coding of transcripts to identify the patterns and themes emerging from the participants’ responses to reflection questions and in experimenting with the haptics. These participant reflections are analysed for practical insights in the iterative prototyping process.

4.3 Embodied Interaction and Soma Design

In this study, embodied interaction informs the design and evaluation of prototypes as well as the design of the workshops. Paul Dourish defines embodied interaction as “the creation, manipulation, and sharing of meaning through engaged interaction with artifacts” (2001, 126). Dourish’s framing argues that tangible human-computer interaction systems must be understood not only through their physical properties, but through how they are “caught up in larger systems of meaning that connect the physical to the symbolic” (2001, 207). Kristina Höök’s concept of soma design further informs this approach by centring bodily awareness and lived sensory experience (Höök 2018). Soma design describes a design process which is intended for technology and design to adapt to the body, rather than for the body to adapt to technology.

The haptic experiences designed in this study are intended to be personal to the individual body and interpersonal relationships rather than a one-size-fits-all approach. Embodied interaction and soma design perspectives inform both the design and interpretation of the prototypes. Haptic experiences have wide variations in user response and preferences, so participant testing offered essential feedback in prototyping and assessing the multi-user haptic social experience of Touchstones. The devices are designed to be held, handled, and physically engaged with, with their form encouraging tactile interaction. At the same time, vibration patterns are not assigned fixed meanings but are shaped through users’ interactions with the devices and with one another.

This study employs an iterative prototyping approach as a method of Research Through Design (RtD). Through the workshops, the collaborative creation of haptic patterns functions as both a design method and a research activity situated at the intersection of RtD, embodied interaction, and soma design. Designing interactions with user evaluation and embodied engagement are core components of the research inquiry.

CHAPTER 5: PROTOTYPE DEVELOPMENT

5.1 Prototype Iteration Outline

This chapter explains the iterative prototyping process of the Touchstones ecosystem. Mirroring the development of each prototype, the discussion is organized by the five core facets of development (see Figure 12): the **physical form and material (A)**, the **GUI (B)**, **haptic vibration patterns (C)**, the **hardware system (D)**, and **wireless communication (E)**.

Figure 12: The Touchstones ecosystem. Sketch by author.

Table 3 outlines the four prototypes developed through this project. This project was actively in development from the summer of 2025 until spring 2026, with the timeline of prototypes demonstrated in Figure 13.

Prototype #	Areas of Development
Prototype 1	• Focused the most on the physical form and materials • Experimented with mini vibration motors and Arduino microcontrollers
Prototype 2	• Tested new materials • Multiples devices instead of just one to explore multi-user communication • Same microcontroller system as the first iteration
Prototype 3	• Began network of multiple devices • Improved hardware system – smaller development board and rechargeable • Device scaled down
Prototype 4	• Similar to previous iteration but slightly improved form and GUI • Wireless communication transitioned from Bluetooth Low Energy (BLE) to a local network system • Group vibration pattern broadcasting as opposed to the previous 1-to-1 sending limitation

Table 3: Overview of prototype iterations.

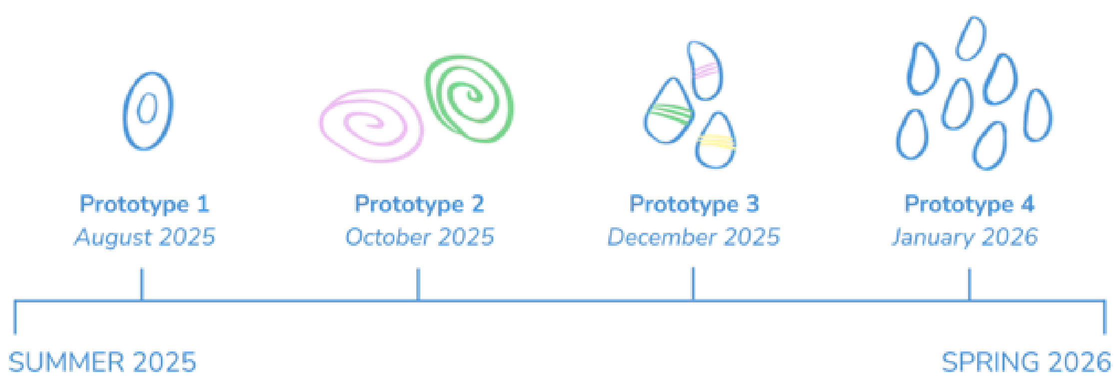

Figure 13: The timeline of prototype development. Sketch by author.

5.2 Form and Material

The physical form of the Touchstones prototype was originally inspired by a worry stone – objects designed to sit naturally within the hand and invite continuous touch. The idea first came from the desire to explore a haptic device which could be worn on the body in many ways, based on user preference. With the wearable or holstered application in mind, I sought to create a device that was small enough to be somewhat discreet on the body, large enough to contain the essential hardware, and smooth to be comfortable – both for potential handheld use and for wearability.

For material, I had considered wood, metal, some form of fabric with conductive thread, or 3D printing. Ultimately, 3D printing and modelling was selected for the ability to create custom and precise 3D objects. As this device is intended to house specific hardware and also be as compact as possible, the precision and efficiency of working with 3D modelling software was appealing.

The first series of prints (1A-1D) for **Prototype 1** were designed in the 3D modelling applications Blender and TinkerCAD. These tools were selected based on previous experience, but after Prototype 1, it became clear that neither platform was suitable for this project. Blender was challenging in creating objects to specific scales and working with a complex mesh, while TinkerCAD was challenging to create the type of custom curved shapes needed for this project.

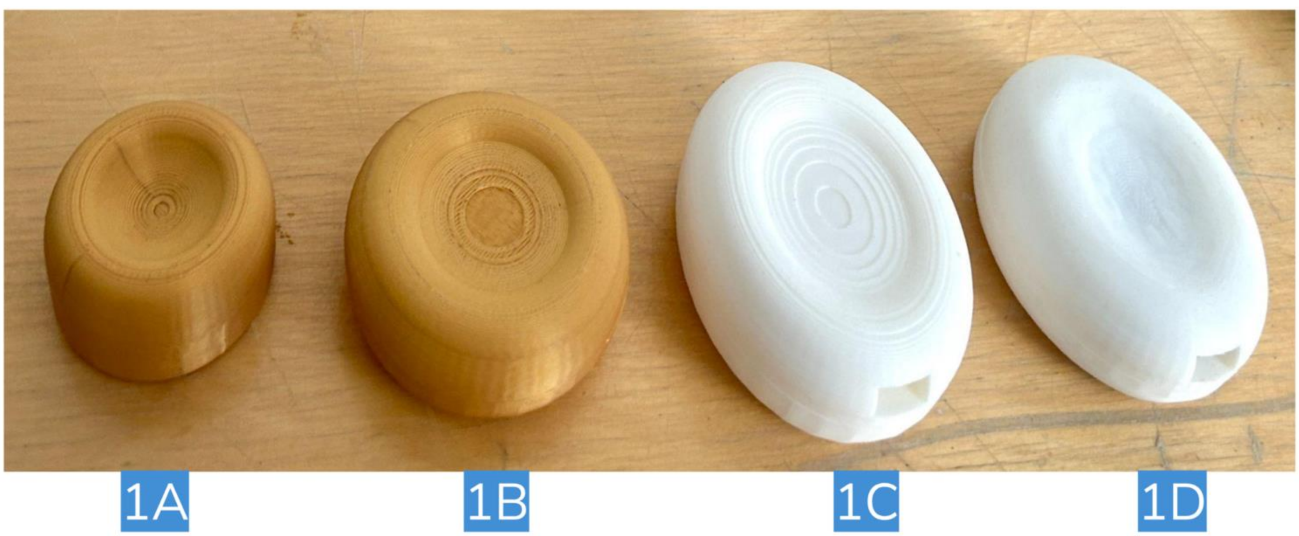

Figure 14: *The first four 3D printed shell prototypes, in order (1A through 1D, left to right).*

Figure 14 demonstrates the progression of the 3D prints in Prototype 1 (1A-1D). The first print (1A) was a test print to try creating an object that was comfortable to hold. It was far too small to hold any of the hardware I planned to use and the thumb divot I added was too deep to be comfortable.

The second print (1B) was larger in scale, flatter, and a bit shorter. It still was too small for the hardware – this was more so an experiment in making changes to a 3D model rather than a true attempt at a suitable prototype.

The third print (1C) was the first where I attempted to use measurements from the hardware to inform the model's internal structure. The hardware fit and the slot I added for a battery connection was the correct scale. This iteration's divot in the top half was deeper than it needed to be, adding unnecessary height, and the print was low quality, creating wide, layered, and uncomfortable rings of filament.

In the fourth and final print for Prototype 1 (1D), the layers were smoothed but the scale remained the same as 1C. It was comfortable in the hand and the scale was correct for the embedded hardware components (see Figure 15). I found the mini vibration motor that was used created an unpleasant rattling noise, but adding pompoms and fabric reduced that and gave it a smoothing effect where the motor affected the entire form. The plastic shell worked well to echo the vibrations across the whole device.

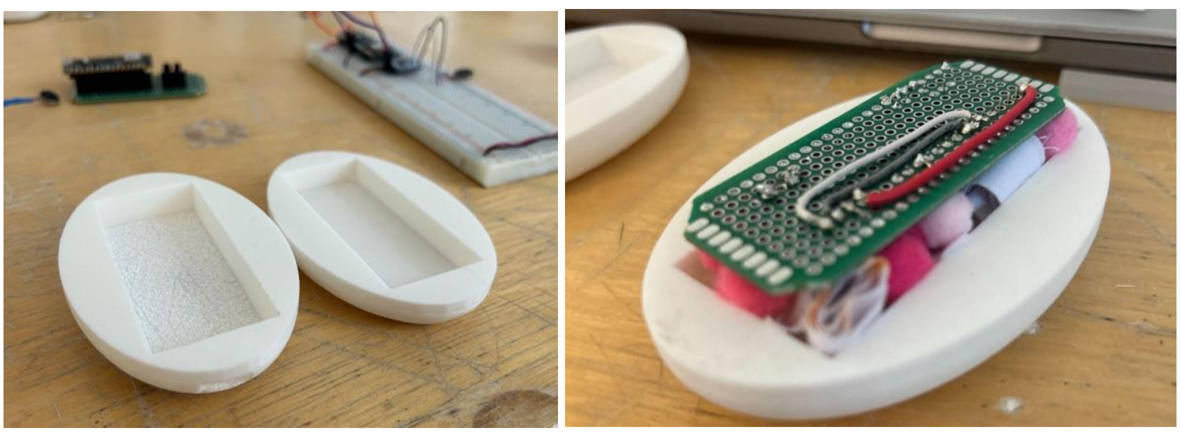

Figure 15: *Internal structure of print 1D and embedded hardware.*

After sharing the first prototype (print 1D) at a class exhibition, I received feedback that the device reminded visitors of a phone or of a vibrator. This was partially due to those being common applications of vibrations in everyday devices, but also because of the form being smooth, white, and perfectly oval. The form was distracting to those who tried it due to these associations.

The next series of prints (2A & 2B) were created in the 3D modelling application Fusion. This tool was far more suitable for the need for precise scale and a wide variety of features for detailed, customized models. Fusion has a timeline feature to allow for editing of past changes which also alter the most updated version – this is incredibly helpful for iterating upon measurements after printing a 3D model.

The first print of **Prototype 2** (2A) moved away from the white, smooth, oval shape of the previous prints. Instead, 2A was larger and more circular, but the thumb divot remained (see Figure 16). The hope was that these changes would maintain comfortability but make the device less misinterpreted as other objects. The internal shape remained the same as previous versions as the hardware did not change. This form also distanced itself from the original wearability goal, instead targeting a handheld experience. After printing, it became clear that 2A was too thin at the top and would be structurally weak.

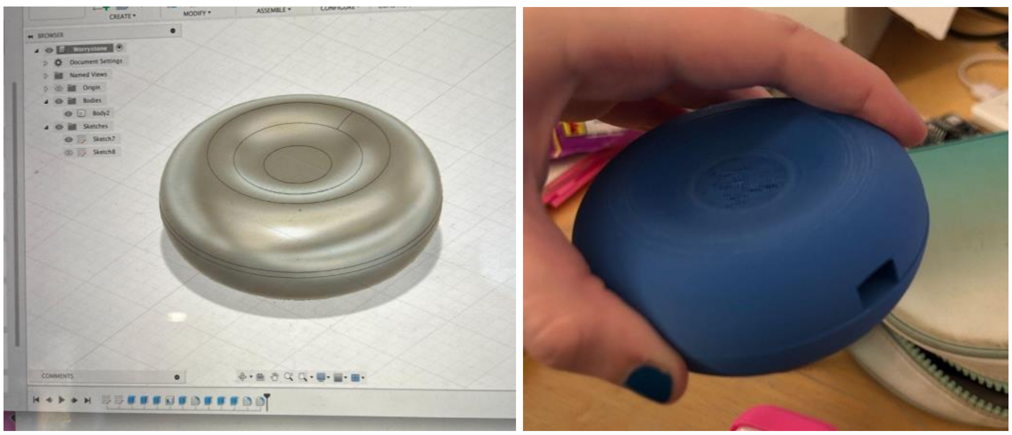

Figure 16: Print 2A: 3D model in Fusion (left) and print (right).

Print 2B resolved the thickness issue and attempted adding two thumb divots as opposed to the original single divot (see Figure 17). This was intended to encourage the device to be held with both hands to offer full attention to the haptic experience.

Figure 17: Print 2B: 3D model in Fusion (left) and print (right).

After both 2A and 2B were printed, the material of the object was not aligned with the intent of the device being a calming and comfortable tactile experience. I initially hoped to add felted sleeves to the devices for a softer texture, as this also would open up customizability and add visual interest, but the idea was out of the timeline scope for Prototype 2 (but would be revisited further on).

A fuzzy and fibrous yarn offered some similar qualities to felt where the fibres could be manipulated into something softer. Wrapping and gluing the yarn tightly around the 3D print softened the devices tactically but also created a more welcoming visual effect. Prints 2A and 2B were used for the final form of Prototype 2, despite their imperfections, as the yarn covered the plastic entirely (see Figure 18).

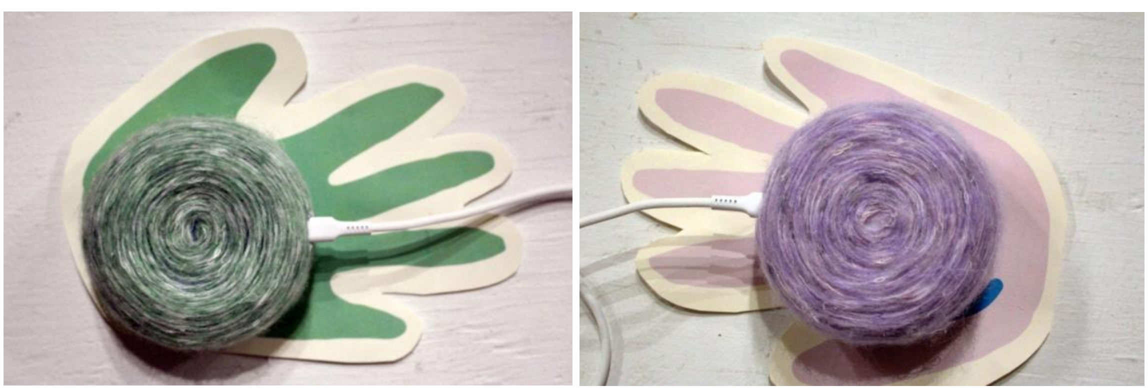

Figure 18: Prints 2A and 2B wrapped with yarn.

After sharing Prototype 2 (prints 2A and 2B) in a class exhibition, concerns about cleanliness due to the yarn being unremovable were raised. Visitors also found the glue texture beneath the yarn to be rough and uncomfortable. This iteration had also been glued shut and was not re-openable, which was challenging for debugging the hardware and impractical in the longer term.

For **Prototype 3** (prints 3A and 3B), I updated the embedded hardware system (see Hardware System) which offered a far more compact scale. This enabled the form to be significantly smaller (in both height and width). The internal structure I had previously used, which was essentially a rectangle cut out of the centre of the shell, was re-considered – it had created a significant amount of wasted empty space.

I also sought to re-consider the external form and improve the tactile experience based on user feedback. Returning to the original idea of a pocked-sized worry stone, the next prints emulated the shape and smoothness of a beach stone – a calming object which is intended to feel smooth for repeated touch. Visual research was conducted to consider approaches to the creation of an organic form. I sketched the forms that appeared to be the most suitable to the natural shape of the human hand in my notebook. These sketches (see Figure 19). were utilized to design the next 3D models.

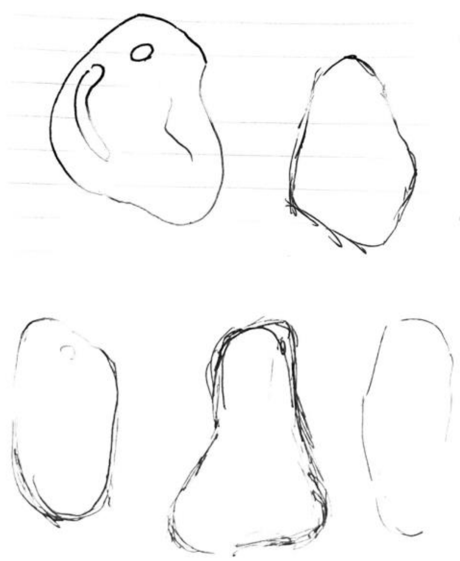

Figure 19: Rock research sketches – scanned from notebook.

The first print of Prototype 3 (3A) was focused on creating the smallest possible form to house the hardware. This included designing the internal structure specifically to fit each hardware component, with nooks and shelves for a secure hold. All the hardware was stacked vertically, which was effective in reducing width, but created an awkward height (see Figure 20).

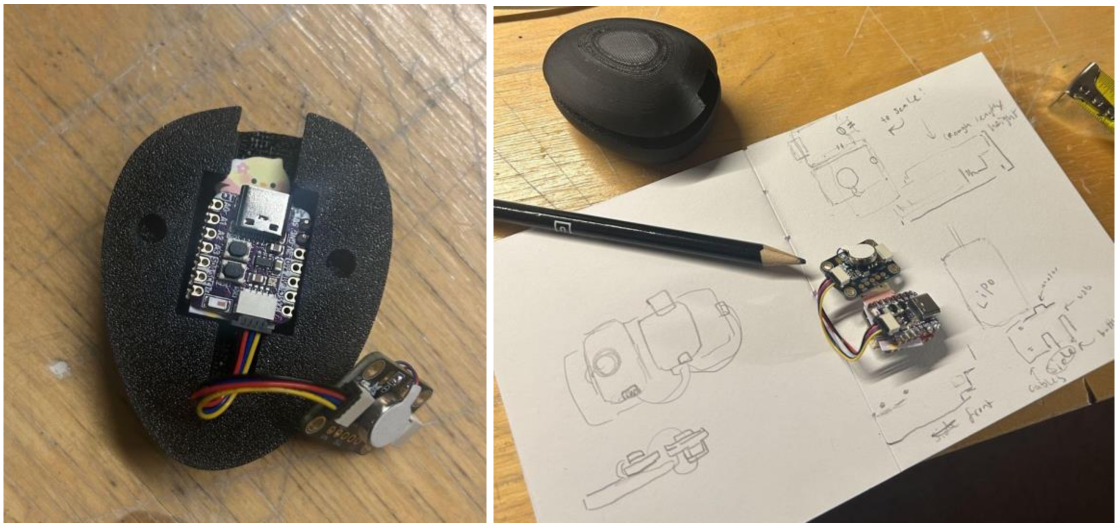

Figure 20: *Print 3A (left), the subsequent sketches for 3B's internal layout (right).*

After printing 3A, I re-considered the internal layout to pivot from the vertical tech stack sandwich into a side-by-side arrangement. This made the device longer but significantly shorter, which was more aligned with the flat beach stone idea and improved handheld comfort.

For print 3B, the beach stone associations deepened in the use of a marble PLA filament. I considered translucent filaments, various colours, metallic or wood finishes, but ultimately selected white marble for its natural appearance.

Print 3B was printed at a low quality for a quick test, which resulted in noticeable layers of filament that were both a pleasant tactile experience and visually appropriate to the stone-like form (see Figure 21).

Figure 21: *Print 3B.*

Two more "stone" shapes were designed to create a network of three devices (prints 3C and 3D, see Figure 22). This was to test out a few stone forms in informal testing to see if users had any preferences of the three options. In the following prints, the infill was increased to add additional weight and enhance the rock-like comfort of holding the device. Magnets were used in all 3 prints to keep them closed, which was enough for the devices to be shared and offered easy access to the internal hardware for debugging.

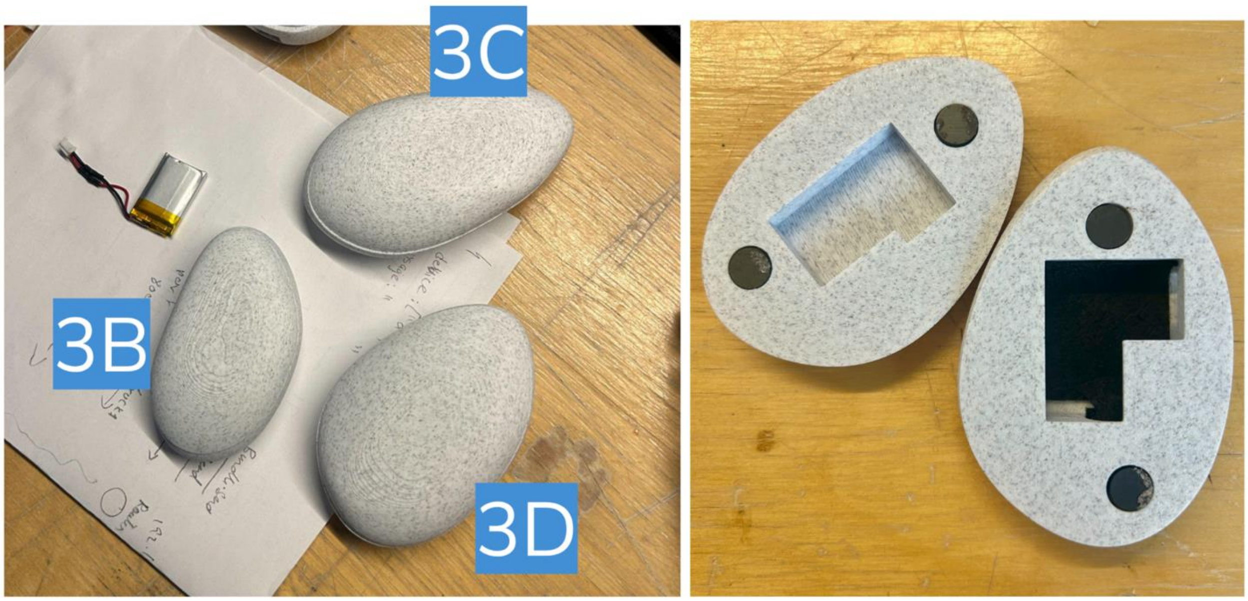

Figure 22: Prints 3B, 3C, and 3D (left) and internal appearance of the three prints (all are the same).

I was satisfied with the visual appearance of the prints for Prototype 3 (3B, 3C, and 3D), but after Prototype 2, which had a fixed material, I wanted to explore a customizable texture for users to swap out if desired. In my rock-related research, I encountered a technique called rock wrapping, where cord, thread, string, yarn, or other materials are used to wrap around stones. This can be just a visual art form, but Japanese rock wrapping also exists as a specific facet of the practice, often done as a relaxing exercise (Masuda, 2021). I tested a minimal version of this idea by wrapping different colours of embroidery thread around the 3 devices (see Figure 23). The intent was to have a textured sleeve to soften the rocks visually, but I received feedback that they looked like rubber bands.

Figure 23: Prints 3B, 3C, and 3D with embroidery thread rock-wrapping technique.

Figure 24 demonstrates the size progression in prints from Prototype 1 to the third, in order (1D, 2B, 3A, 3B, left to right).

Figure 24: The size progression of prints, in order.

The rock-like 3D printed shells on the haptic devices of Prototype 3 were very positively received in a university program-wide exhibition. For the most part, the form of 3B persisted from

Prototype 3 to **Prototype 4** – the comfort and visual appearance of this form was something I wanted to carry into the next prototype. I selected the most comfortable and compact of the three designs (print 3B) I had made in the previous iteration and multiplied it. For Prototype 4, the internal structure was refined for the embedded hardware and I developed a custom snap-fit closure. The magnets from the previous iteration were at risk for the shell opening if the device were dropped, posing a danger for the hardware inside. A snap fit closure was a secure solution that allowed the shell to continue to be two halves and for hardware to fit on both sides to make the most of the internal space.

The snap fit I designed uses two pegs on either end of the shell with a curved protruding bump (see Figure 25). This offers a secure hold, but the curved bump still allows for the top to come off relatively easily with pulling force applied. These rounded pegs snap into the matching slots on the other half of the shell. Perfecting this took five iterative prints with tiny, fraction-of-a millimetre adjustments to the model each time. This kind of closure is easy to make too loose to stay securely closed or too tight to be re-opened.

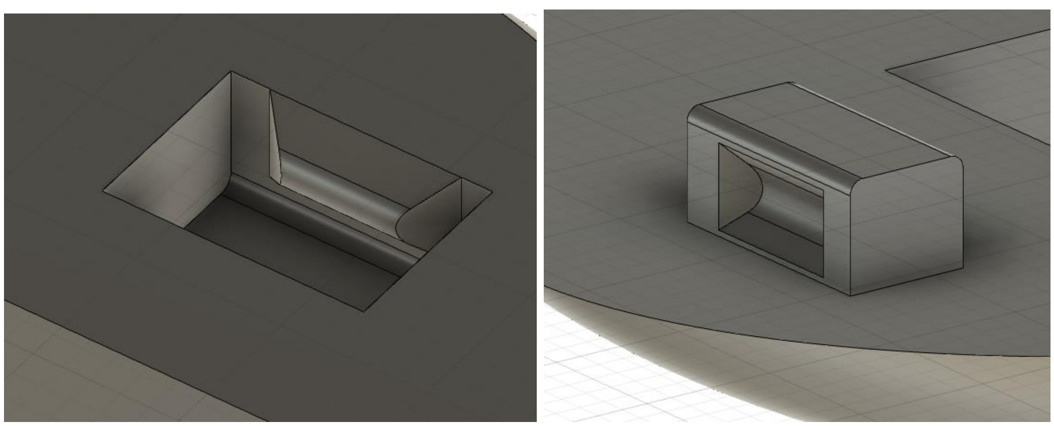

Figure 25: *Bottom (left) and top (right) halves of the snap fit I designed for Prototype 4 in Fusion.*

Figure 26 demonstrates the full 3D model I designed in Fusion for Prototype 4. The shell is divided into two halves to fit the hardware inside and uses a custom snap fit closure. The dotted line view displays the internal structure, which was designed to fit the exact hardware components inside.

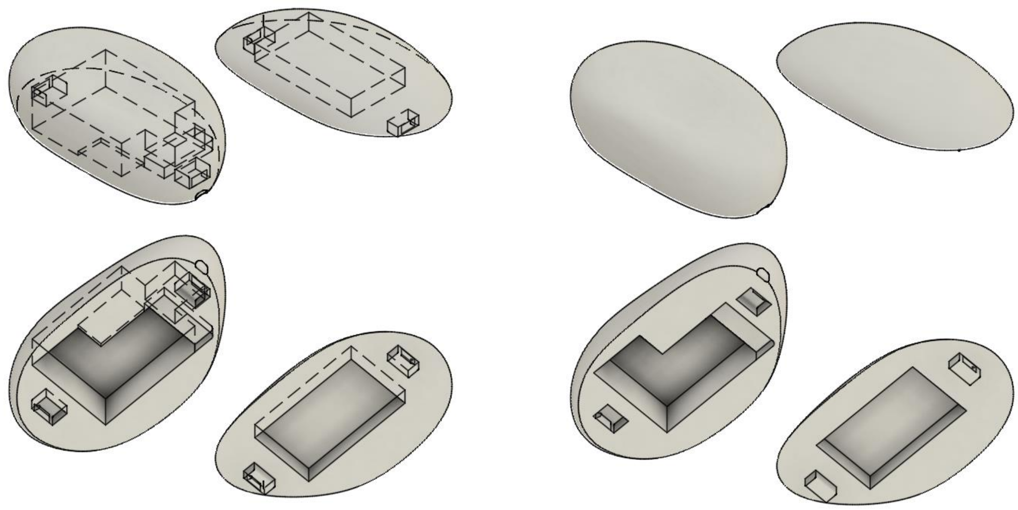

Figure 26: Full 3D model for Prototype 4.

For this iteration, I created seven units, so I produced seven identical printed shells to house the hardware. This was the final physical form for the Touchstones – user feedback on this form was consistently positive, praised for its ergonomic design, everyday appearance, compact size, and layered texture. Figure 27 shows the hardware fitting securely inside the 3D printed shell for Prototype 4 and the full family of seven Touchstone devices.

Figure 27: Fourth prototype internals (left) and seven Touchstone devices (right).

5.3 Graphical User Interface (GUI)

To facilitate communication between Touchstones, a Graphical User Interface (GUI) was developed over the course of the prototyping process. Initially designed for mobile phones and later adapted for tablet screens, the interface evolved to support more detailed visualizations. This section focuses on the development of the GUI, which aimed to encourage the creation of meaningful vibration patterns.

A GUI rather than physical buttons on the Touchstones or an alternate solution was selected for several reasons. This project is grounded in my background as a graphic and web designer, where my experience with web-based interactive systems informed both the approach and practical scope. Additionally, at the early stages of prototype development, the goal was to build a tool for tactile communication across distances for friend groups (where it would be important to know who was sending what messages). Managing a rolodex of friends would be impossible without a detailed interface for identification, which a GUI can manage.

Prototype 1, a proof-of-concept, for which the GUI was designed as a remote-like mobile phone application (see Figure 28). It was a simple interface with three buttons, each corresponding to one of the developed haptic patterns (see **Haptic Vibration Patterns** section of this chapter). Selecting a button on the webpage triggered the associated vibration pattern on the device. This iteration was shared in an informal class exhibition, where visitors could not test the vibration patterns themselves – it was limited to my own phone.

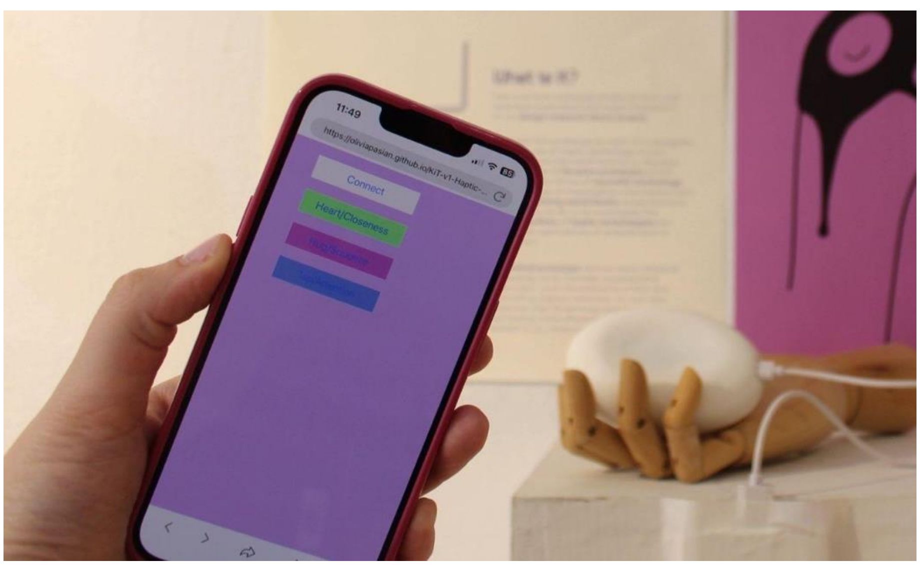

Figure 28: Prototype 1 GUI.

Prototype 2 (see Figure 29) sought to rectify the limitation of a single person able to interact with the GUI. This iteration was designed to be used without needing to provide facilitation, exploring how users might actively participate in creating and sending their own haptic messages. To assist, the screen size moved up from a mobile phone to a Samsung Galaxy tablet (see Figure 30), enabling a more detailed single-page interface. The design was inspired by a soundboard – a panel of square buttons, each of which produced a different vibration effect. There was a total of twelve buttons on the board: three pre-made sample patterns, to provide context, and nine single vibration effects. These were "building blocks" inviting users to string together their own pattern.

Each effect was selected from the Adafruit DRV2605L motor driver library (see **Hardware System** section of this chapter). This library offers 123 pre-built vibration effects with a wide range of intensities and lengths. The nine single effects in this iteration were chosen to represent a range of available haptic sensations, including a sample from the categories offered, which include buzzes, clicks, transitions, and hums. I gave the options I selected the following effect titles: Strong Click, Long Buzz, Double Click, Soft Bump, Buzz, Ramp Up, Ramp Down, and Flutter. The names were offered to give users some sense of what the effect might be. This selection was intended to provide users with a manageable yet representative toolkit for experimenting with and constructing their own haptic patterns.

Figure 29: Screenshot the Prototype 2 GUI, created in p5.js.

Figure 30: Prototype 2 GUI on a tablet.

Feedback for Prototype 2 was focused on issues correlating the single vibration names to the output pattern. Visitors were confused about the correlation and did not know what to expect from the output vibration based on the button name.

Prototype 3 (Figures 31 & 32) sought to resolve this issue in creating a clearer visualization of the output, as well as a more intuitive and engaging way for users to design haptic patterns. Using p5.js, the GUI for this iteration replaced buttons with a canvas where users could manipulate a series of draggable points to generate a waveform. After drawing a waveform and selecting the output physical device, users could hit a “Send Waveform” button to send the waveform data as a felt vibration on a Touchstone.

Figure 31: Screenshot of the Prototype 3 GUI, created in p5.js.

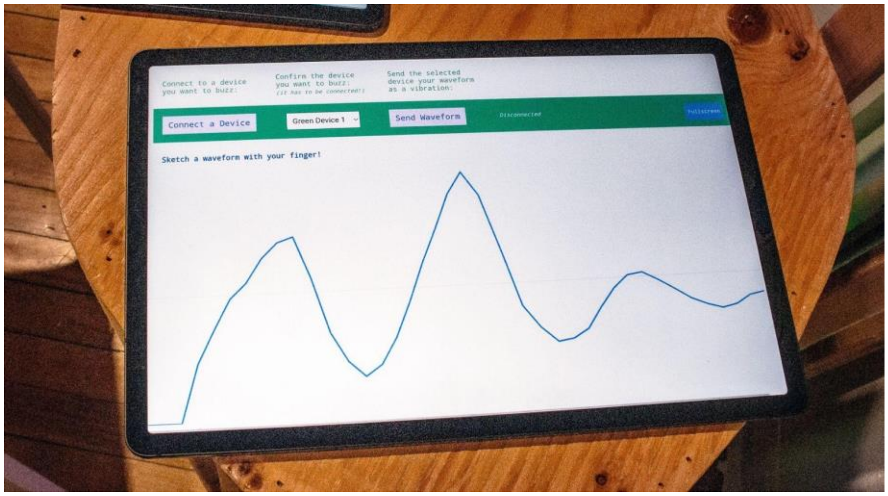

Figure 32: Prototype 3 GUI on a tablet.

The system continued to use the Adafruit DRV2605L motor driver, mapping waveform data to different vibration intensities based on vertical position. For example, if the point in the array was in the top 30% of the Y-axis on the canvas, it would be mapped to effect 47 in the library, which had a high vibration intensity. There were five total effects as the canvas was split into five invisible sections, so depending which area of the Y-axis the point fell into, that would determine which of the 5 possible vibration intensities would be emitted. 5 effects were selected which gradually increased in intensity to make it feel as though the higher points in the waveform were more intense vibrations and the lower points were lower intensity. This was to create a waveform that felt accurate visually to what was played out of the haptic device.

In sharing Prototype 3's waveform drawing tool, the feedback was generally positive as far as engagement and this iteration resolved the major disconnect between visualization and output. The prototype was shared in a university program exhibition, not formal user testing, but it was noted that visitors attempted to design patterns more so based on the visualization than with a pre-intended communicative meaning. For example, drawing a jagged dramatically increasing and decreasing intensity levels to make a friend laugh at the shape of the pattern. Visitors were also iterating upon their waveform drawings to see the impact of the visual changes upon the output vibration – many noted that the output was not what they had expected from the visualization of the waveform.

Prototype 4 (Figures 33 & 34) was very similar in functionality to the third. Only minor adjustments to the waveform mapping to vibration intensity were made, to improve the translation from visualisation to output. This prototype was developed for the Haptics Tapas workshop series, which included four pre-made sample patterns (see **Haptic Vibration Patterns** section of this chapter). For this purpose, four buttons were added to the top of the screen to emit each sample to the

Touchstone device. This iteration of the GUI also removed the need to select a device to send to, as hitting the "Send Waveform" button would broadcast the pattern to all connected Touchstones (see **Wireless Networking** section of this chapter).

The major change in this iteration was a re-design of the visual identity – the waveform tool appeared the same, but buttons and titles were more organized and responsive to changes in screen size. Labels were added to indicate the maximum vibration length of three seconds on the x-axis and "more intense" and "less intense" vibrations on the y-axis. Feedback from workshop participants noted that these labels were useful, but matching visualization to output was again an issue.

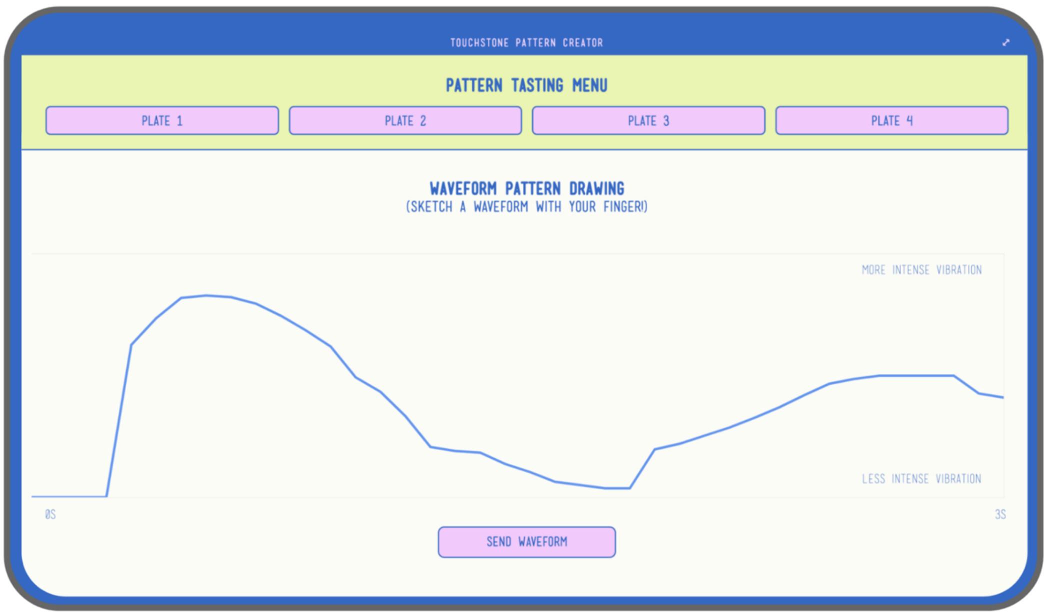

Figure 33: Screenshot of the Prototype 4 tablet interface.

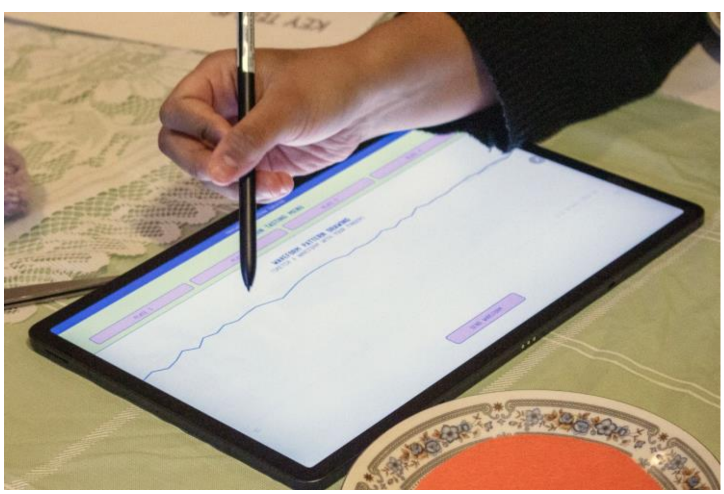

Figure 34: Prototype 4 GUI on a tablet.

5.4 Haptic Vibration Patterns

Programming vibrations crosses both software and hardware – the **Hardware System** and **Graphical User Interface (GUI)** sections of this chapter contain more detailed information on those aspects of the vibration pattern development process. This section instead focuses on the self-reflective process of designing vibration patterns with communicative intent during prototyping.

While Touchstones are intended to support users in creating personalized haptic patterns, I developed a set of pre-made sample patterns during both the initial and final prototyping stages. These patterns first functioned as a proof-of-concept and were later used to provide users with a clearer sense of the system's communicative application.

For **Prototype 1**, I developed three vibration patterns – sequences of vibrations of varying intensity. I chose to create three as a sampling for a proof-of-concept and selected three "meanings" to develop the patterns around: a pattern mimicking a heartbeat with the intended message to be a feeling of closeness and shared space; a pattern that emulated a squeeze or hug (by creating a pattern which started strong, pulsed, and slowly faded out); and a pattern that acted like a tap on the shoulder (quick short pulses like a tap or notification).

The first attempts at visualising the patterns I sought to create were linear sketches based on vibration intensity increasing and decreasing (see Figure 35). Each straight horizontal line represents a consistent vibration intensity, with the length representing a rough duration estimate. The upwards arrows represent a gradual increase in vibration intensity and the downwards arrows are a gradual decrease in vibration intensity. For both upwards and downwards, the horizontal length of the arrow is a rough duration estimate, representing how quickly or slowly the intensity changes.

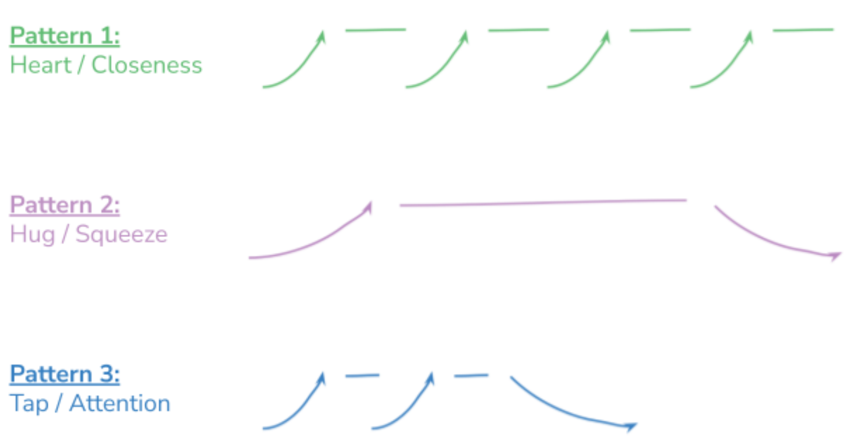

Figure 35: Initial sketches of the Prototype 1 vibration patterns as lines. Sketch by author.

The process of designing vibration patterns with meaning was iterative, as I moved between concepts of what I thought would "work" and what the output feeling was. This was a process guided by personal motivation and self-reflection. The three patterns were abstract and early feedback received was conclusively a response of confusion. Those who interacted with the three output vibration patterns of Prototype 1 found all of them unclear. The only pattern which had some understanding was the "Tap / Attention" pattern, which was compared to a notification vibration on a mobile phone.

In Prototype 1, these were the only interactions users had with the Touchstones system. There was not yet an opportunity to design a personal pattern. This was added in Prototype 2, which included the original three vibration patterns as well as 9 individual "single" vibration intensities (see **Graphical User Interface (GUI)** section of this chapter).

Prototype 2 was shared in a class exhibition, and many of the visitors did not attempt to construct a pattern. Instead, they enjoyed sending each other the pre-made patterns or testing the single vibrations.

Prototype 3 did not offer any example vibration patterns and instead focused on encouraging users to play with the interface, without prompting, to send each other vibrations.

In the final phase of pattern development, **Prototype 4** brought back the inclusion of sample patterns on the GUI as well as the waveform drawing tool. This was added for the Haptics Tapas formal testing workshop sessions, which focused specifically on gathering groups of friends to design their own communicative or meaningful vibration pattern. More details regarding the facilitation (6.1) and outcomes (6.3) of the workshops can be found in the **Haptics Tapas Workshop** chapter.

To contextualize tactile communication to participants of the workshop, I designed four new "example" patterns to demonstrate different approaches to designing a vibration with communicative meaning. The four examples I chose to create were 1. Poke, 2. Hold, 3. How-are-you, and 4. Cheers. Each was three seconds in length. Sketch visualizations of what the programmed waveforms look like can be seen in Figure 36. Table 4 describes the four patterns and the intended meaning of each.

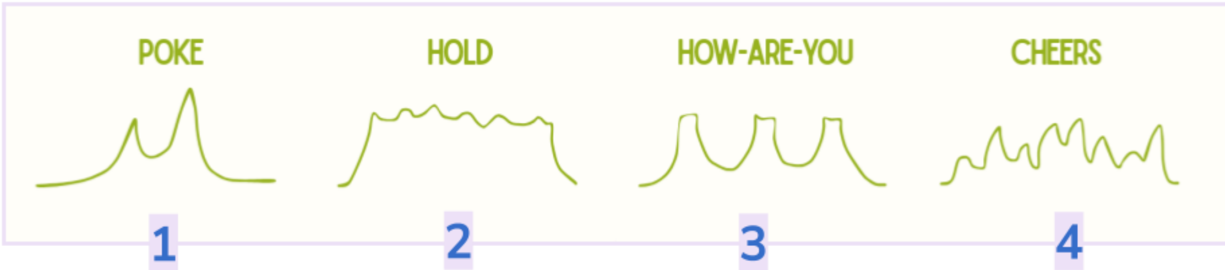

Figure 36: The Prototype 4 sample vibrations, sketch by author. From left to right: 1. Poke, 2. Hold, 3. How-are-you, and 4. Cheers.

Pattern	Description
1. Poke	• Sequence of two consecutive pulses with the second pulse being slightly more intense than the first • Literal approach, with the intent of mimicking existing text notification vibrations • Also intended to represent a real "poking" gesture, using two nudges of vibration emulating a fingertip poke
2. Hold	• Long sequence of repeated pulsing vibrations with slightly varying intensities • Abstract approach to imbuing meaning, attempting to represent a hug or being held through a long vibration
3. How-are-you	• Sequence of three pulses of the same intensity • Another literal approach, with the intent of translating the syllables of the phrase into vibrations
4. Cheers	• Sequence of random varying intensities of vibration • Another abstract approach, this time to a real phrase, intending to create a sparkling effect which meant "thank you" or "cheers"

Table 4: Descriptions of each sample pattern created for Prototype 4.

The final four patterns of Prototype 4 and the original three from Prototype 1 were both designed through iteration based on personal preferences and meaning. In the Haptics Tapas workshops, I did not share the pattern meanings with participants until after emitting them as vibrations through their Touchstones. They generally did not understand the meanings I tried to imbue the vibrations with. In the process of designing their own patterns, they came up with vibrations that had meaning exclusive to their group.

5.6 Hardware System

This section discusses the development of the hardware system embedded in each Touchstone haptic device. The hardware encompasses microcontrollers, vibration motors, and power management and is divided into two iterations: Prototypes 1 and 2 used one system, while Prototypes 3 and 4 used an updated system.

I chose to work with tactile reception – specifically vibrotactile feedback – for this project over other haptic modalities (such as temperature or body motion), partly due to the accessibility of vibration motors. They are relatively inexpensive, technologically simple, and well-supported in haptics research (see **Literature Review**). The hardware system utilizes mini pancake ERM vibration motors throughout the entire prototyping process. ERM stands for Eccentric Rotating Mass, as these little motors use a small, unbalanced weight attached to a DC motor shaft to create vibrations when spun ("ERMs").

Initial testing with the ERM vibration motors revealed a key limitation: without a significant amount of extra microcontroller programming, the motor could only produce simple on/off outputs. Creating variations or full waveforms of vibration intensity would be difficult and time-consuming if I were to code them from scratch. To expand the range of possible haptic vibration intensities, a haptic motor driver (Adafruit DRV2605L) was added to the hardware system in Prototype 1 (see Figure 37). This provided access to a built-in library of predefined vibration effects (ex. clicks, pulses, buzzes and transitions) that could be sequenced into more complex waveform patterns. This addition sped up the programming process and was used in every iteration.

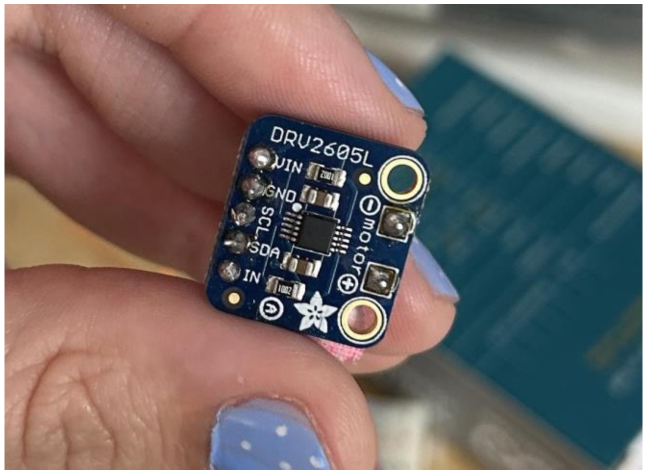

Figure 37: The Adafruit DRV2605L Haptic Motor Driver used in early prototype development.

For **Prototypes 1 & 2** (see Figure 38) the hardware system was made up of an Arduino Nano (first the Arduino Nano 33 IoT, then the Arduino Nano 33 Sense), an Adafruit DRV2605L Haptic Motor Driver, a mini ERM vibration motor, and an external 5V rechargeable battery for power. The Arduino Nano and the Bluno Beetle were evaluated for integration with the motor driver for early iterations, as both are compact and the versions I used had BLE capabilities for wireless communication. Although the Beetle was designed for wearable applications, its size was comparable to the Arduino, leading to the decision to proceed with the Nano due to familiarity and ease of use. This entire hardware system was soldered to a 3cm x 7cm PCB board and placed inside the early Touchstone device iterations.

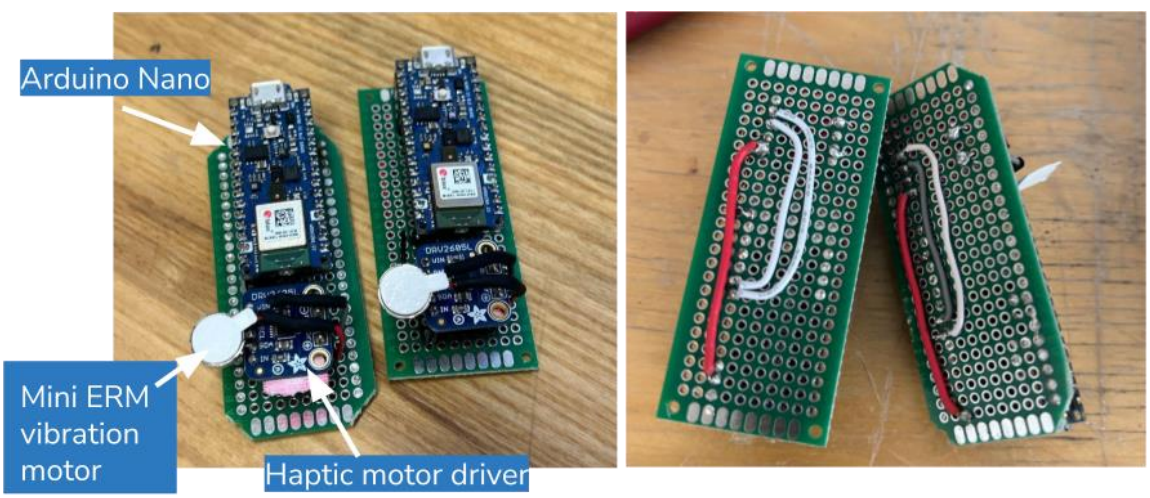

Figure 38: Internal components of Prototype 1 and 2: top view (left) and bottom view (right).

For **Prototypes 3 & 4**, reliance on BLE had become a limitation (see **Wireless Communication** section of this chapter) and the scale of the Arduino Nano was large enough to add a lot of bulk to the Touchstones. The original system also relied on power from an external source. I saw a peer, Juan Sulca, use the Adafruit QT Py microcontroller in his project *TinkerPod* (Sulca 2025) for a similarly small-scale device. The QT Py microcontroller offers versions with both BLE and WiFi and is approximately 2cm x 2cm. Comparatively, the Arduino Nano is close to 5cm long and 2cm wide.

The QT Py also is compatible with Adafruit's LiIon / LiPo battery charger, the "BFF." This addition offers power management to use and charge a Lithium Polymer (LiPo) battery safely, which was added to the updated hardware system for an internal battery. The BFF stacks directly onto the QT Py, adding only 5mm or so in height. Figure 39 shows me soldering them together.

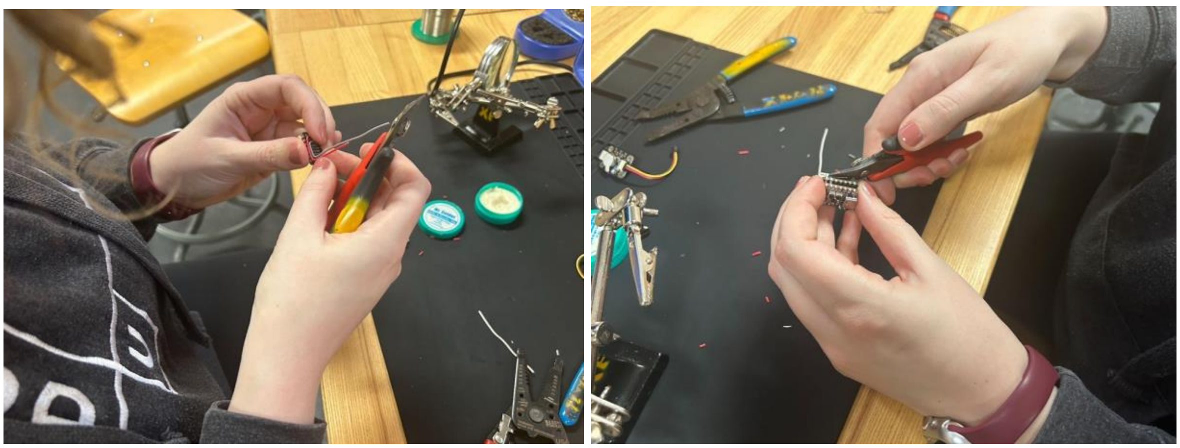

Figure 39: *Images of me putting together the QT PY systems in the fabrication lab at OCAD University.*

The QT Py I selected is the Adafruit QT Py S3 with 2MB PSRAM, WiFi, and STEMMA QT. The "STEMMA QT" is a plug-and-play system from Adafruit, which adds a JST port to many of their devices and sensors to remove the need for breadboards or soldering to wire things up. For the Touchstones, this meant that the microcontroller (QT Py) and haptic motor driver (DRV2605L) with attached mini ERM vibration motor could be directly and securely connected without the bulk of a PCB or breadboard. It saved space and enabled a compact, stackable hardware system – Figure 40 demonstrates three of these updated systems, minus the LiPo batteries. The multi-coloured wire is the STEMMA QT connection.

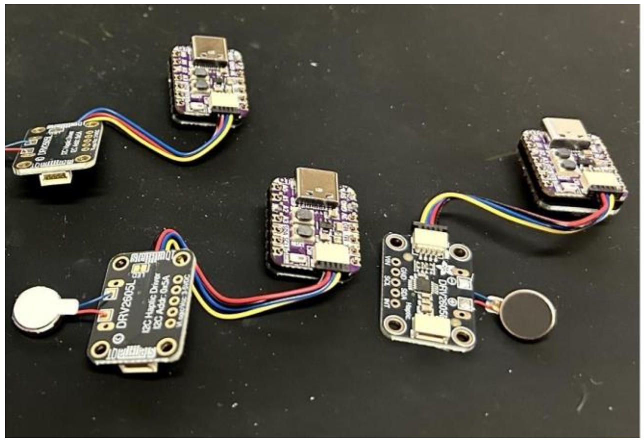

Figure 40: The Prototype 3 & 4 QT Py systems.

With the Lithium Polymer Battery, QT Py, battery BFF, haptic motor driver, and mini vibration motor, the system was complete. Both Prototypes 3 & 4 consistently had no issues with this hardware and scaling up the number of devices was a smooth building process. Figure 41 shows the full, final system, annotated with each part.

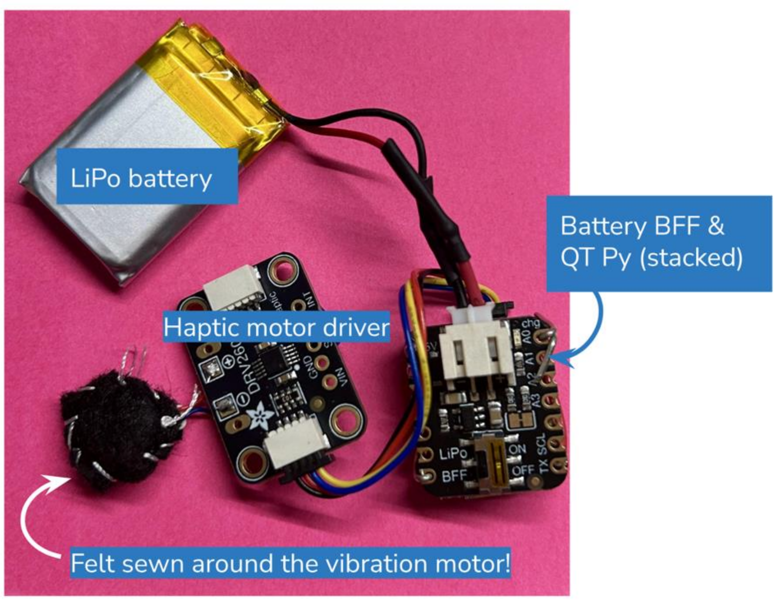

Figure 41: The hardware system for Prototype 3 & 4.

5.7 Wireless Communication

This section discusses the development of wireless communication between Touchstone devices and the GUI for transmitting vibration patterns. The number of Touchstones in each iteration increased, from one device at the beginning up to seven by the end. Navigating wireless communication between an increasingly large network of devices (both Touchstones and GUI) was a challenge and learning curve.

Prototype 1 focused on establishing basic wireless communication between a mobile interface and a single haptic device. Bluetooth Low Energy (BLE) and WiFi were initially considered, but BLE was selected due to prior experience and its suitability for low-power, short-range communication.

A web-based interface was developed using p5.js (see **Graphical User Interface (GUI)** section of this chapter), allowing a mobile device to trigger output on a microcontroller via BLE. Initial exploration focused on testing the communication between the webpage and the microcontroller through a simple LED circuit before attempting to control the vibration motor. Due to limited BLE support on iOS, a specialized browser application was required to enable the use of the application on an iPhone.

Once a stable BLE connection was established, the system was extended to control a mini vibration motor. The interface was expanded to include three buttons, each corresponding to a predefined haptic pattern. Selecting a button triggered the associated vibration on the device (see Figure 42). At this stage, the system supported wireless control of a single device, serving as a proof-of-concept rather than the intended goal of a fully networked communication system. Figure 43 demonstrates Prototype 1 in use: a single person using the device and sending the haptic patterns.

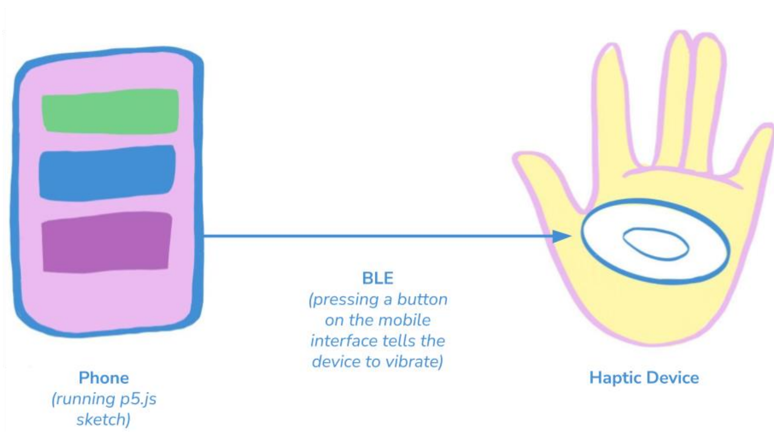

Figure 42: The network diagram for Prototype 1. Sketch by author.

Figure 43: Prototype 1 in use.

For **Prototype 2,** the same core circuit was reused to test whether BLE could support communication between multiple devices. The goal for this prototype was to connect at least three devices, but the limitations of BLE quickly became apparent. I found that BLE does not easily support seamless multi-device networks or simultaneous broadcasting from a single interface. The intended functionality had been either sending a vibration pattern to all Touchstones at once or selectively targeting individual devices. This would have required a microcontroller with WiFi connectivity and a more complex backend system. As the Nano 33 Sense microcontroller I had used does not support WiFi, this approach was not feasible within the scope and timeline of Prototype 2.

As a result, the system was limited to one-to-one communication between devices. Though one-to-one communication was not my intended application, it served as an effective sample to try the prototype. In a class exhibition setup, the BLE constraints were worked around by pairing devices separately to simulate a multi-user interaction (see Figure 44). Figure 45 demonstrates Prototype 2 in use: two users facing each other with the GUI used to send haptic patterns to the opposite person's device.

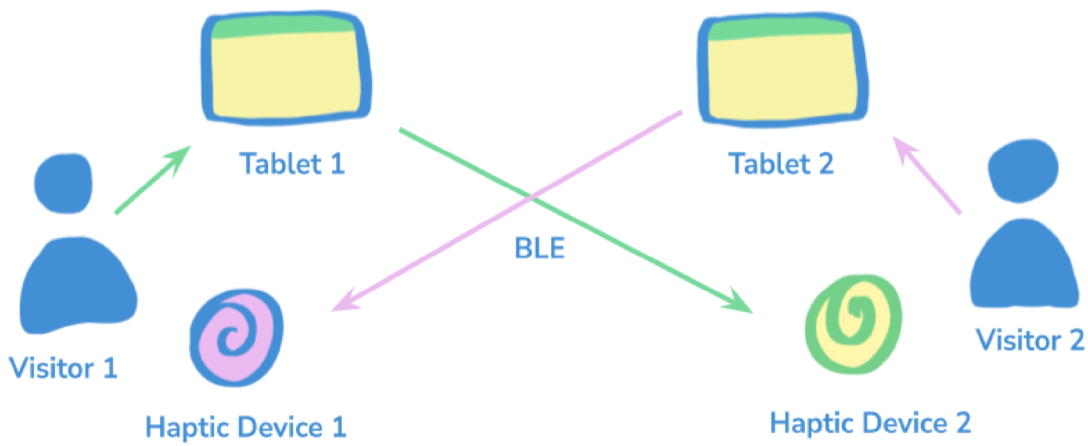

Figure 44: The network diagram of the exhibition setup for Prototype 2. Sketch by author.

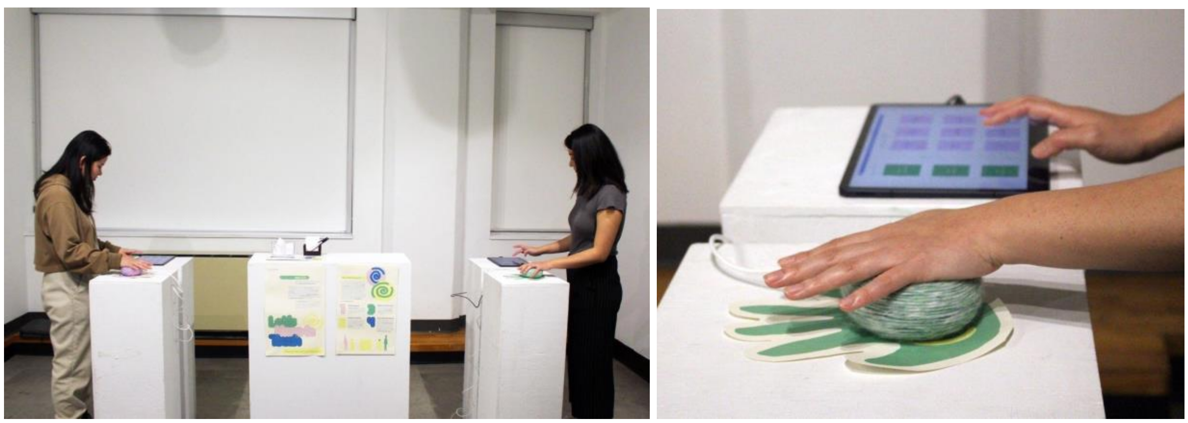

Figure 45: Prototype 2 in use.

By **Prototype 3**, the limitations of BLE for the intended purpose of the Touchstones system were evident. A new hardware system with WiFi connectivity was added, but the need to host a server and create a local network exceeded the project's scope and timeline, so BLE was retained for this iteration.

Prototype 3 increased the system to three devices, aiming to introduce group dynamics beyond one-to-one interactions. This expansion revealed challenges related to sender identification, multi-device communication, and remote interaction. While this study's original intent was to explore tactile communication at a distance, implementing cloud-based hosting and robust sender management was beyond the project's scope.

In a university program-wide exhibition, this prototype was showcased with a similar format to Prototype 2, where the number of devices was equivalent to the number of tablets running the GUI (see Figure 46). The BLE limitation of only being able to connect to one device at once meant I had to connect each tablet to a different device before sending a vibration pattern. To manage this, the interface included a “Connect” button to activate the Bluetooth selection pop-up and a dropdown to select the device ID from a JSON file. While functional, this process was cumbersome and created a confusing user experience. A status indicator showing “connected” or “disconnected” was added to help clarify active connections.

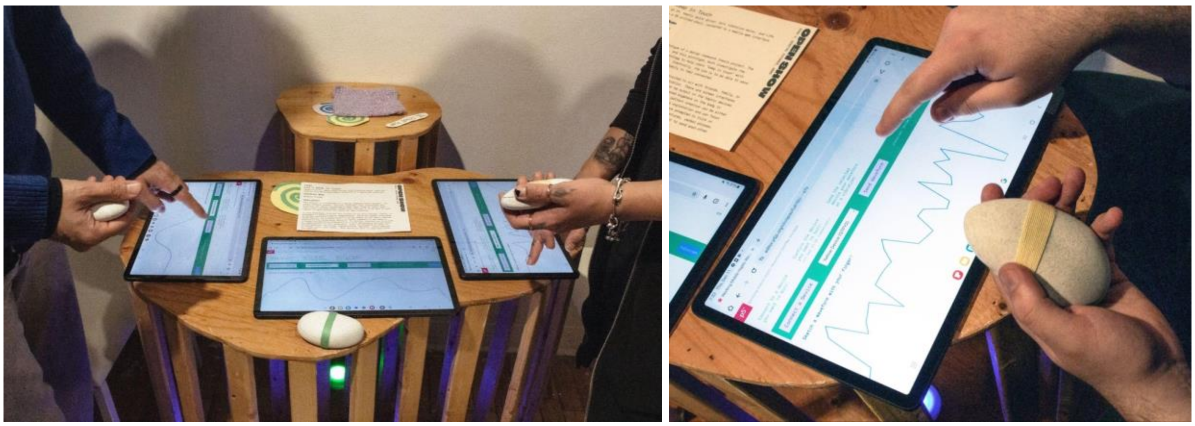

Figure 46: Prototype 3 in use.

The most significant update in **Prototype 4** was the shift from BLE to a local area network (LAN). Unlike BLE, which limits the number of simultaneously connected devices and requires individual pairing, the LAN allows all Touchstones to connect automatically to WiFi when powered on. Static IPs were assigned to each device on the network to enable consistent targeting of vibration patterns. Without this addition, identifying specific devices would have been unreliable. Communication over the LAN is faster and more stable than BLE, supporting multi-device interaction.

In the Prototype 4 setup, as demonstrated in Figure 47, the laptop hosting the Node.js server was connected to the router via Ethernet, while all Touchstones and tablets connected wirelessly over WiFi. Data from the waveform drawing GUI was sent over WiFi to the router, routed via Ethernet to the laptop, and then transmitted back over the LAN using UDP packets to the targeted Touchstones by their fixed IP addresses. Each QT Py microcontroller on the Touchstones received the message and triggered the haptic motor driver to play the corresponding vibration pattern.

This setup enabled broadcasting a waveform to all devices simultaneously by including all Touchstones’ IPs in a server array. This supported the intended collaborative experience of designing and sharing patterns in real time, enabling multiple participants to interact with the system simultaneously (see Figure 48).

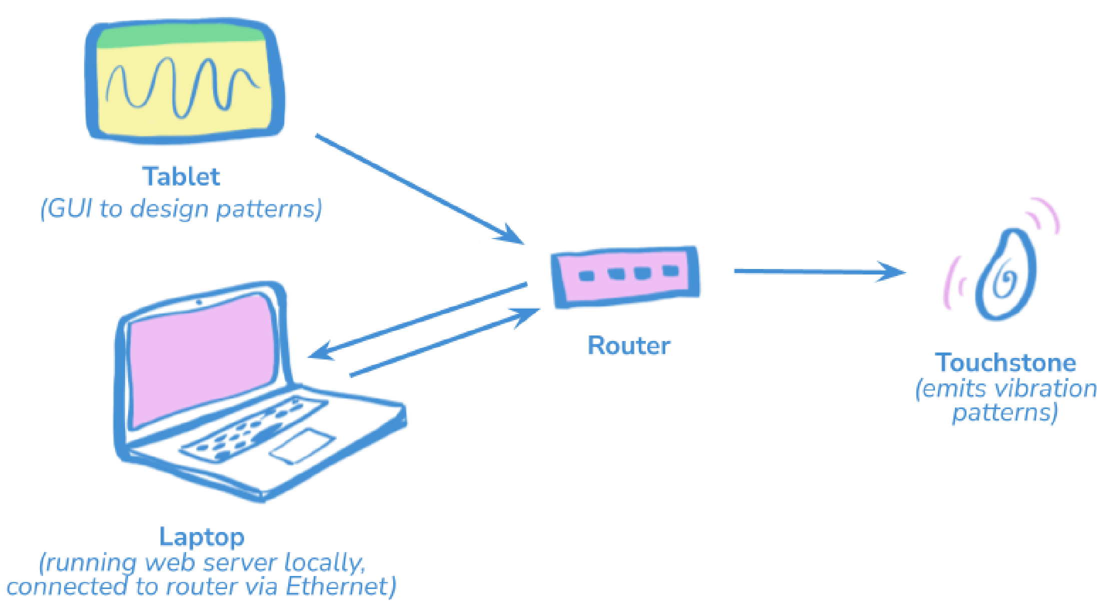

Figure 47: The network diagram for the final prototype. Sketch by author.

Figure 48: Prototype 4 in use.

5.8 Prototype Reflections

5.8.1 Strengths and Challenges

Table 5 summarizes the strengths and challenges of each prototype developed. Each prototype informed the development of the next iteration through a combination of self-reflection and sharing with others. These summaries are from my own reflections on feedback I received, technical issues, and personal preferences of what was strong and what needed improvement in each iteration.

Prototype #	Strengths	Challenges
Prototype 1	• Early explorations with mini ERM vibration motors, Arduino microcontrollers, and Bluetooth Low Energy (BLE) – hardware and software tech both worked! • 3D printing and modelling was effective to efficiently create a physical form to house the device's hardware	• Graphical User Interface (GUI) was very minimal, three buttons on a mobile phone screen which each played a vibration pattern on the physical device • The form of the device was compared to a soap bar, a vibrator, and a phone • Only a single device, not representative of my goal for communicating between multiple
Prototype 2	• The visual design was effective, with the tablet screen providing ample space for text and buttons • The texture and overall appearance of the haptic devices were engaging and enjoyable	• Button labels did not clearly indicate vibration output • Two devices only, limited scalability as BLE only allowed one-to-one communication, and the Arduino Nano 33 Sense lacked WiFi • The large form of the devices was awkward to hold and not wearable, and the fixed material raised cleanliness concerns • Battery packs were unreliable, cords were unsightly

Prototype #	Strengths	Challenges
Prototype 3	• Waveform drawing was more reliable to translate visuals to vibration patterns than buttons, also offering greater customization than previous iterations • The Marble PLA shells were praised for their tactile weight and "rock-like" aesthetic • The QT Py system was reliable and has compact, contained hardware and a rechargeable battery	• Vibration output is inconsistent and does not accurately reflect waveform drawings • The current magnet closure is insecure, and BLE limits the system to one-to-one communication • Three devices in the system, limited due to cost
Prototype 4	• The Touchstone form, now with a snap-fit closure and layered texture, was well-received for its comfortable, handheld feel. • The GUI visuals were tidied and the network was updated so vibration patterns can be sent to all devices without manual selection • The QT Py system continued to perform reliably	• The system can only send vibrations to all devices simultaneously, with no way to select recipients or identify senders • The translation from waveform drawing to vibration output remains imprecise

Table 5: Prototype strengths and challenges.

5.8.2 Summary of Final Prototype

Figure 49: The final Touchstones physical prototype from several angles.

The final prototype outcome of this design research study is a set of seven physical "Touchstone" haptic devices (see Figure 49) and accompanying software to design, send, and receive vibration patterns.

The user scenario for the final prototype was within a workshop setting, where each participant had a Touchstone and designed personalized patterns to share in groups (see Figure 50). The patterns were designed on tablets using the GUI and emitted to all participants' Touchstones. This collaborative design process was intended to investigate the communicative potential of vibration patterns within social networks (see **Haptics Tapas Workshop** chapter).

Each Touchstone contains an embedded hardware system composed of a mini ERM (eccentric rotating mass) vibration motor, a Lithium Polymer (LiPo) battery, and Adafruit components including a QT Py microcontroller, haptic motor driver, and LiPo charger. Each device has an approximate battery life of three hours.

The devices are housed in 3D-printed shells designed to accommodate the internal components through a custom snap-fit closure and tailored internal structure. The external form prioritizes handheld comfort, drawing on the typology of worry stones. The print was intentionally set to a lower quality, producing subtle ridges that evoke a fingerprint-like texture.

The GUI was built with p5.js and Node.js to enable users to draw waveforms on a tablet and send them to the Touchstones as vibrations. This waveform drawing tool collects the points of the waveform and translates them to an appropriate level of vibration intensity – a higher amplitude in the waveform translates to a higher intensity of vibration output.

Figure 50: Prototype 4 in Haptics Tapas workshop session.

CHAPTER 6: HAPTICS TAPAS WORKSHOP

Figure 51: Images from the Haptics Tapas workshops of participants testing out Prototype 4.

As a method to test the prototypes and learn about haptic communications in use, I developed a workshop series, “Haptics Tapas.” Participants were invited in January and early February of 2026 and a total of seven participants (over two workshops) took place in 2.5-3hr workshop sessions. Both sessions followed the same facilitation plan, designed by me, drawing on ideas from methodologies including soma design (Höök, 2018), reflective design (Sengers et al., 2005), and generative design (Sanders & Stappers 2016). The workshop was approved by the Research Ethics Board at OCAD in December 2025 (approval #2025-74).

Workshops were held in the Social Body Lab on the OCAD University campus in intimate and cozy evening sessions (see Figure 51). Participants were recruited through flyers and email announcements through the university and recruitment sought pre-existing friend groups with a maximum of 8 participants in a single workshop session (see **Appendix A**). The shared exploration of vibrotactile patterns generated qualitative knowledge about imbuing patterns with meaning, social applications of haptics, and collective interpretation of nonverbal communication. These findings contribute broader insights into group-based haptic communication beyond the prototype itself.

The name “Haptics Tapas” comes from the tasting menu and small shared plates style format of the workshop, but rather than food, participants were served an introductory sampling of vibrotactile feedback. For participants, the learning goals included an introduction to the basics of haptic technology, exploration of the emotional and communicative potential of various haptic patterns, and the development of a shared and personalized haptic communication method.

Prototype 4 was used in facilitating the workshops. This included the physical haptic devices, "Touchstones," as well as two tablets with a waveform drawing GUI that were used to design and send vibration patterns.

The first group of friends who participated in a workshop was a group of 3 interdisciplinary graduate students from OCAD University who share a studio. The second group of friends who participated were a group of 4 recent graduates from OCAD University, a mix of interdisciplinary and Digital Futures program grads. Both groups were both classmates and friends outside of school.

6.1 Workshop Overview

The workshop was broken down into six sections: Welcome, Intro to Haptics, Tapas Time, Brainstorm, Make & Play, and Share & Reflect. See **Appendix A** for the facilitation plan. Data was collected through recordings, transcripts, participant-created artifacts (sketches and waveform patterns), and observational notes. These materials were reviewed and coded to identify recurring themes in pattern creation, meaning-making, and group interaction, informing the final iteration of the prototype.

First, participants were welcomed into the space, and the outcomes and intent of the workshop were explained. The toolkit participants would work with – Touchstones, the waveform drawing interface, and pen and paper (see Figure 52) – were explained, noting what the Touchstones were and that they'd be the vibration emitters. Each participant had a Touchstone in front of them and there were two large tablets, to be shared and used as a point of collaboration, which had the waveform drawing tool interface on them. I informed the group that the patterns designed on the interface would be output to all the devices at once, again for the purpose of collaboration.

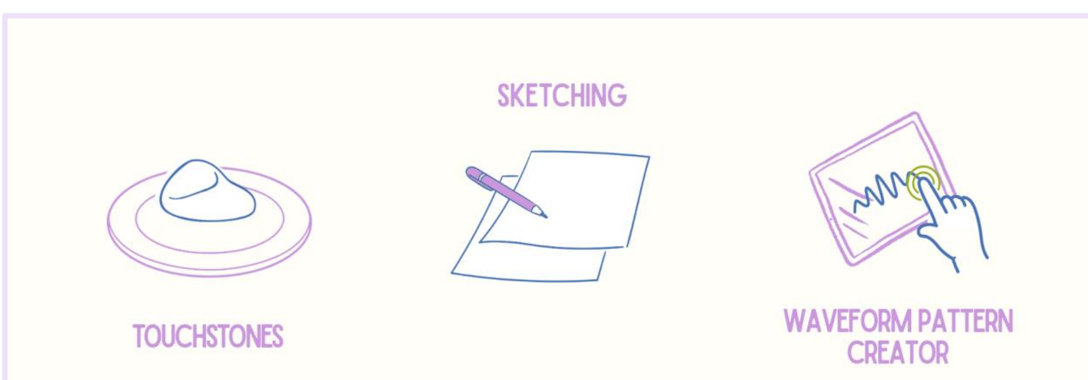

Figure 52: Tools slide from the presentation for the workshop facilitation.

The second section, “Intro to Haptics”, was a brief introduction to the basics of haptic technology. Key terms, such as vibrotactile feedback, waveforms, and amplitude were defined and explained in the context of the workshop (see Figure 53). I used mobile phones and game controllers as a point of reference for everyday encounters with haptics (specifically vibrotactile feedback) and how haptic feedback refers to information gathered from our sense of touch, comparable to how we gather information through sight and sound (“Haptic Technology 101”). The goal of this section was to offer participants the same base knowledge and terminology to use throughout the workshop, as participants were not expected to have any prior knowledge.

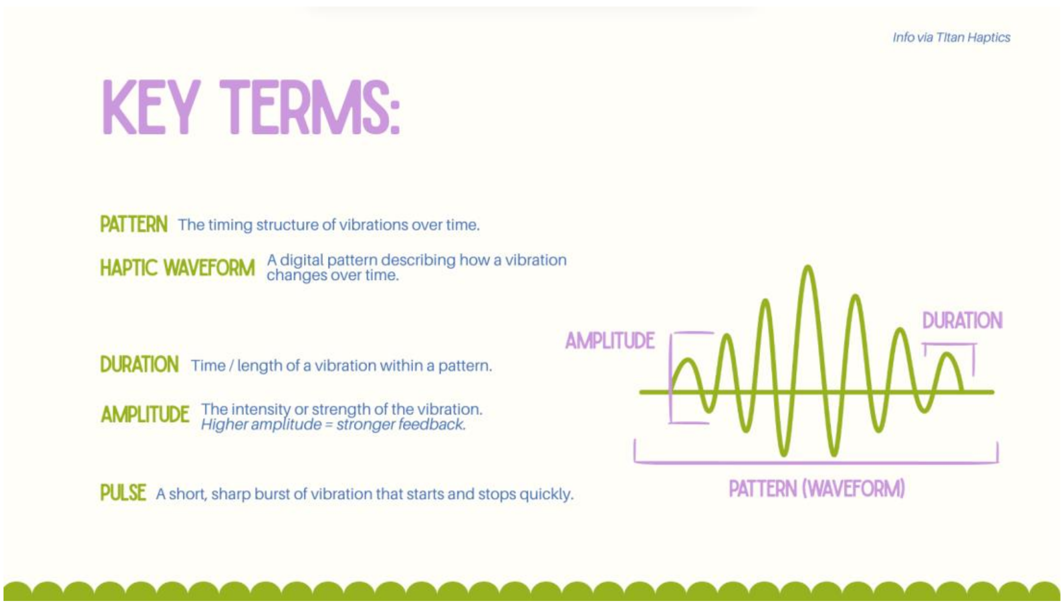

Figure 53: Key Terms slide from the presentation that I made for the workshop facilitation.

The third section of the workshop, “Tapas Time”, was the tapas-style display of vibration patterns. Rather than a tasting menu of food, participants were introduced to a tasting menu of 4 vibration patterns that I created. Each “plate” (pattern) was designed based on a gesture, phrase, or other communicative meaning that I came up with, but they were played for participants ***without sharing the intended meaning***. The goal was to have participants begin thinking about the way a vibration could be imbued with a personal meaning (and how it might only make sense to those who created it) and demonstrate a few methods for how to approach this idea. The **Haptic Vibration Patterns** section of the **Prototype Development** chapter includes further detail about these four sample patterns.

I offered rough waveform pattern sketches for each pattern to help participants develop an understanding of how visualizing a vibration could be approached. Based on Sanders & Stappers generative design "Say" technique of free-form questions (2016, 68), I encouraged participants to guess at the meaning I intended or come up with their own. I asked: "What does this remind you of (if anything)? What does it feel like?" At the end, having played all four patterns, I revealed the intended names and meanings of the vibration patterns. This offered grounds for discussion in comparing what I had intended and how I approached it, versus what participants interpreted. For this discussion, I offered prompts to learn more about instinctual feelings towards the patterns played and vibrations with meaning generally:

- *Which patterns were of interest or stood out?*
- *If you could send one of these to someone, who would it be and why?*

The fourth section, "Brainstorm", was where I asked participants to build upon the base library of knowledge provided and think about how haptics could be applied for communication in their own friend group. Participants were invited to think about what kind of meaning, phrase, or other communication they would want to turn into a communication. First, I offered a short solo brainstorming period, asking participants to come up with ideas on their own for what message they might want to send their group as a vibration. I prompted this section with a callback to the Tapas Time and how those vibrations were formulated – their pattern could be based on an abstract representation of a phrase or gesture, a literal syllable translation of a word or saying, a drawing, an emotion, or anything else that came to mind. I suggested they could use the drawing tools offered to take notes or sketch ideas out in whatever method of visualization made sense to them.

The second half of the brainstorming session was collaborative planning, where participants discussed the ideas they had come up with on their own and some potential directions for the shared communication, they would be working on together. As a group, they were asked to decide on a direction (or a few) and discuss and use their drawing tools to visualize how their intended meaning could turn into a vibration pattern. To prompt this collaborative planning, I offered the previous vibration patterns from Tapas Time again as a reference if needed and encouraged visualization in any way that made sense to them. Waveform sketches, lines, morse code, or even sounding it out were suggested to try and communicate the length, pattern, intensity of the vibration they wanted to create. I remained available to prompt, encourage, and to bounce ideas off of, with the end goal of this section to be to agree on a direction of intended meaning and ideas for how to approach the vibration output.

Ahead of the fifth section, “Make & Play”, I offered a short break for snacks and beverages. The Make & Play section involved the transformation of their idea into an output vibration on their Touchstones. This section began with a tutorial on the two tablets with the waveform drawing interface. I reminded the group that the patterns designed on the interface would be output to all the Touchstones at once, for the purpose of collaboration. I demonstrated by drawing a waveform and outputting it on their Touchstones, then offered them a few minutes to explore on their own. I explained that the drawing tool took in a series of points on the drawn waveform and would emit them to the Touchstone devices. The two tablets were intended to be shared amongst the group, so a few participants could work together on each tablet and go back and forth sending communications with the other group to develop their vibration pattern. The Make & Play section was loosely structured to allow for explorative play, but participants were guided into working on the pattern meaning they came up in brainstorming and turning it into a felt vibration. Iteration was highly encouraged for this section for the group to settle on a final pattern that they felt reflected what they had intended to make.

The second half of Make & Play began with a body tapping exercise, loosely based on an Emotional Freedom Technique (EFT) tapping tutorial from the Cleveland Clinic (“What Is EFT Tapping?” 2024). I invited participants to stand and, if they felt comfortable doing so, to use their fingertips, palms, or cupped hands to tap symmetrically on their bodies. I offered a diagram of some key points (for example, the side of the eye, right on the bone) where the tapping was known to offer stress relief or be calming. This was intended as a body warm-up ahead of asking participants to play with adding textured materials and with placing their Touchstones and emitting their vibration pattern on various parts of the body. After the body tapping exercise, I introduced the various supplies on the table, which included felt sleeves for the Touchstones, pipe cleaners, straps, large safety pins, carabiners, key rings, crochet squares, elastic cord, and lanyards with clips. Participants were given free rein to play with any materials they wanted to add to the Touchstone or to try attaching the Touchstone to their clothes.

I had three questions up on the presentation screen to guide this part of the Make & Play section:

- *How does placing different materials on the Touchstone affect the experience of interaction?*
- *How does placing the Touchstone on different areas of the body affect the experience of interaction?*
- *If you had a pouch for your Touchstone anywhere on your body, where would you place it?*

The sixth and final section of the workshop was “Share & Reflect”, which prompted participants to reflect on the workshop experience. This served as an essential data-collection instrument. The questions I asked were addressed to the group as a whole for open discussion and based on the core aspects of the prototype: the GUI, the physical form and material of the Touchstones, the effect of wearability for the use of Touchstones, the ability to craft meaning out of vibration patterns, group dynamics, and collaboration for design process (for both participants and myself). The questions I asked were:

- *What was the experience of using the tablet interface to design a waveform and sending out a signal?*
- *What was the experience receiving a signal on your Touchstone?*
- *What patterns did you come up with that you were most excited about?*
- *How did it feel to work together to develop a pattern?*
- *How might you see yourself using this kind of haptic communication in daily life?*

6.2 Workshop Setting

A key aspect of the workshop facilitation plan was the setting. The workshops took place in evening sessions and were marketed in recruitment as being a fun social activity for groups of friends, akin to other social creative workshops (ex. pottery classes, wine & painting nights). It was important to set the space up to be inviting and comfortable to achieve a similar “vibe,” both out of appreciation for participants volunteering their time and to ensure the environment of the workshop was supportive of group dynamics. This is partially where the “Haptics Tapas” name came from, in the effort to create an experience rooted in sharing something new in bite-sized portions. Embodied interaction was part of the inspiration for this idea as well, to invite participants into a space where interacting with the devices was staged as both physical artifacts and a symbolic environment of the use case (Dourish 2001, 207).

It was already dark outside when the workshops took place, so lighting was an important factor. The original lights in the space were fluorescent and bright, so I removed half the bulbs and swapped the others for warmer lights, to create a cozier space. The room included a large table in the centre, surrounded by comfortable chairs, and I was seated in the furthest corner from the door to welcome participants in (see Figure 54). The table was set up with tealights, flowers, a tablecloth, and place settings emulating a real tapas tasting, with plates, paper placemats, and drawing tools instead of utensils (see Figure 43). Small dishes with various craft materials were set in the centre for the “Make and Play” section, for participants to explore crafting wearable holsters and trying different body placements with the Touchstones. There were snacks, tea, and hot chocolate available for participants, which was well-received after the halfway break and added to the relaxed environment. There was also a large screen in front of the table which housed a slideshow for sharing workshop materials – the slides matched the table setting and the screen brightness was adjusted to be a similar warmth level to the rest of the lighting (see Figure 55).

Figure 54: The table set-up and workshop environment, which remained the same for both workshops run.

Figure 55: Facilitating the second workshop.

6.3 Workshop Reflections

I planned this workshop with several learning outcomes: I sought to gather opinions on the look and feel of the physical form of the prototype as well as on the usability, visual design, and accuracy of the GUI. I also wanted to explore a collaborative meaning-making design process for participants and learn about on-body and material preferences.

As outlined in The Facilitation Plan, data was collected from responses to direct questions asked to participants, generated artifacts (such as images of sketches), as well as from personal observations and other comments made throughout the workshop. The summarized data from the audio transcriptions from both workshops has been organized into a table in **Appendix A**. The reflections below are analysis from all generative design outcomes of the workshop, with the analysis method loosely based on the "on the wall" analysis approach from the Convivial Toolbox (Sanders & Stappers 2016, 212). The table was created to organize the "messy" qualitative data from the workshops and conduct light analysis in organizing key themes and insights. My reflections on the workshop findings are broken down into 6 areas of data collection: Sending & Receiving Signals, Patterns Designed, Form and Material, Wearability, the Collaboration Experience, and Usability in Daily Life.

6.3.1 Sending and Receiving Signals

Aspects of the waveform tool GUI impeded the design process for participants. All participants commented that the waveform drawing did not feel accurate to their felt output vibration. The participants who noted positive experiences with receiving patterns were with the patterns with a known, pre-discussed meaning. The sending and receiving of tactile communications appeared to work best with simple patterns and with pre-defined meanings. The novelty of the waveform drawing was appreciated, but the interface needs major revisions – participants had suggestions such as saving and replaying patterns, looping, snapping points, guides, and sliders for frequency/intensity.

No issues were reported with feeling the vibrations and no delays in receiving a signal. The hardware worked reliably, which I had not expected to have issues with as I had used the hardware for the previous prototype iteration. Having success with five devices running at once informed me that the wireless communication setup would continue to work for the final prototype.

6.3.2 Designing Patterns

Participants explored a wide range of ideas for vibration patterns, often drawing on familiar rhythms and shared references. The first group settled on a heartbeat pattern to communicate care or “thinking about you,” while the second group proposed patterns such as short pulse sequences for casual greetings (“yo! sup!”), sustained vibrations to mimic a squeeze or hug, and expressive rhythms like “yoohoo!” or an Indigenous drum beat. Participants were particularly interested in how non-linear forms, like shapes or textures, might be translated into time-based vibration patterns. Additional concepts included recognizable patterns (ex. “shave and a haircut,” Morse code), as well as more abstract or sensory-inspired ideas such as a cat purr, bubbles, or the feeling of being in water. Across groups, the process was collaborative and generative, with participants building on one another’s ideas.

The first group utilized the drawing tools more than the second. Figure 56 includes two of the sketches which the first group created, representing the interest in non-linear waveforms and their decision to create a heartbeat pattern.

A few of the final patterns designed on the GUI are visible in Figure 57. The use of two tablets was generally useful and encouraged collaboration by grouping participants together over the interface.

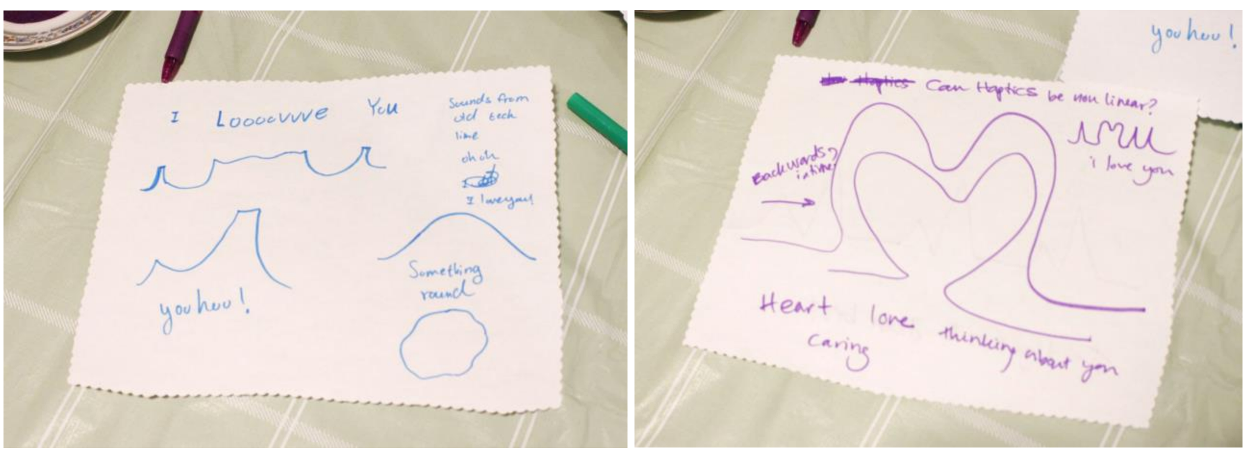

Figure 56: A few of the brainstorming sketches participants made during the first workshop.

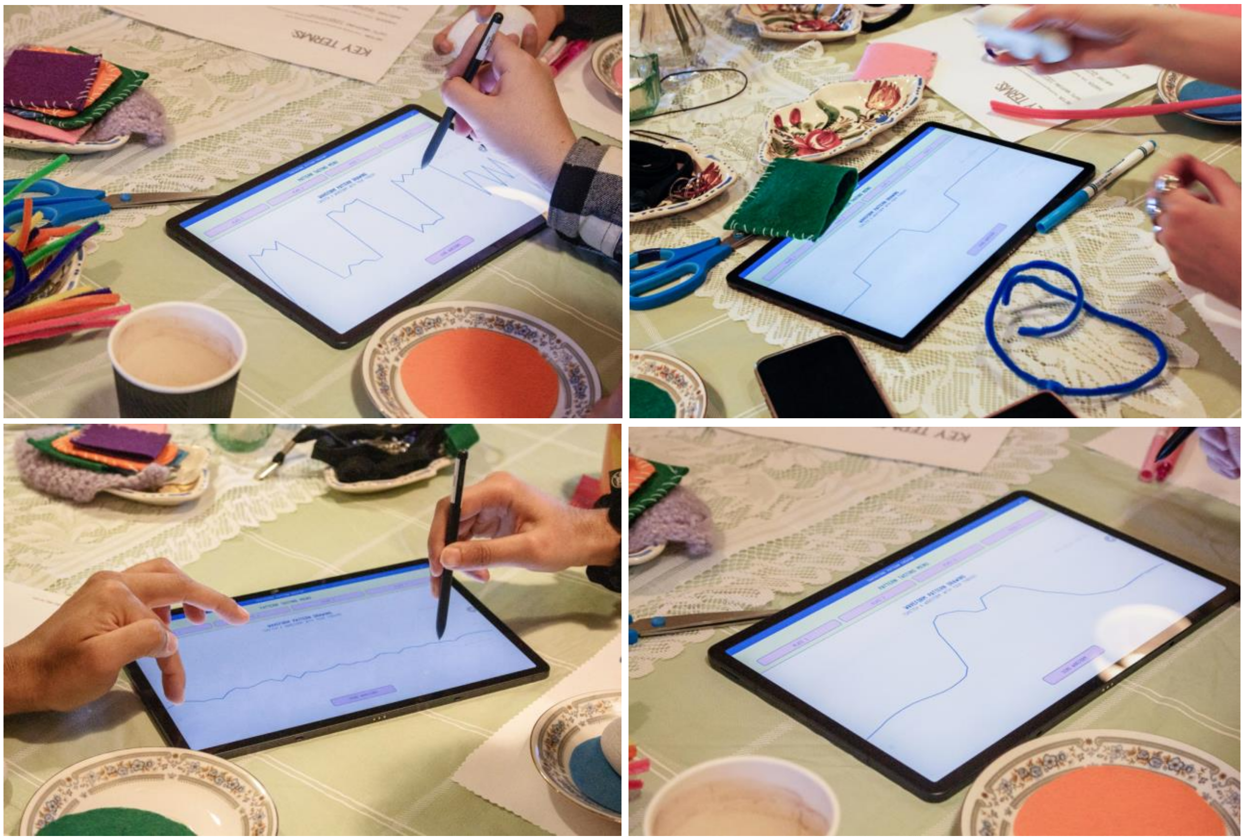

Figure 57: Some of the patterns created using the waveform creation interface across workshops.

6.3.3 Form and Material

The Touchstone's 3D printed, layered texture and ergonomic shape were appreciated widely by participants. All participants in the workshops commented on how much they enjoyed the way it fit their hand or appreciated that it did not feel overly technical. This feedback informed me that I should continue working with this iteration's material and form.

6.3.4 Wearability

For wearability and body placements of haptic devices, participants noted that the chest, wrist, and inner arm placements were most effective; these provided clear tactile feedback and one participant noted the chest felt emotionally powerful as it was like a heartbeat. Layered clothing and hanging placements, such as a keychain or belt loop, reduced vibration perception. Participants were interested in integrating the Touchstones with existing wearables (such as fitness bands, straps) rather than carrying a standalone object.

Figure 58 includes a grouping of the body placements tried in the first workshop, while Figure 59 includes the placement examples from the second workshop.

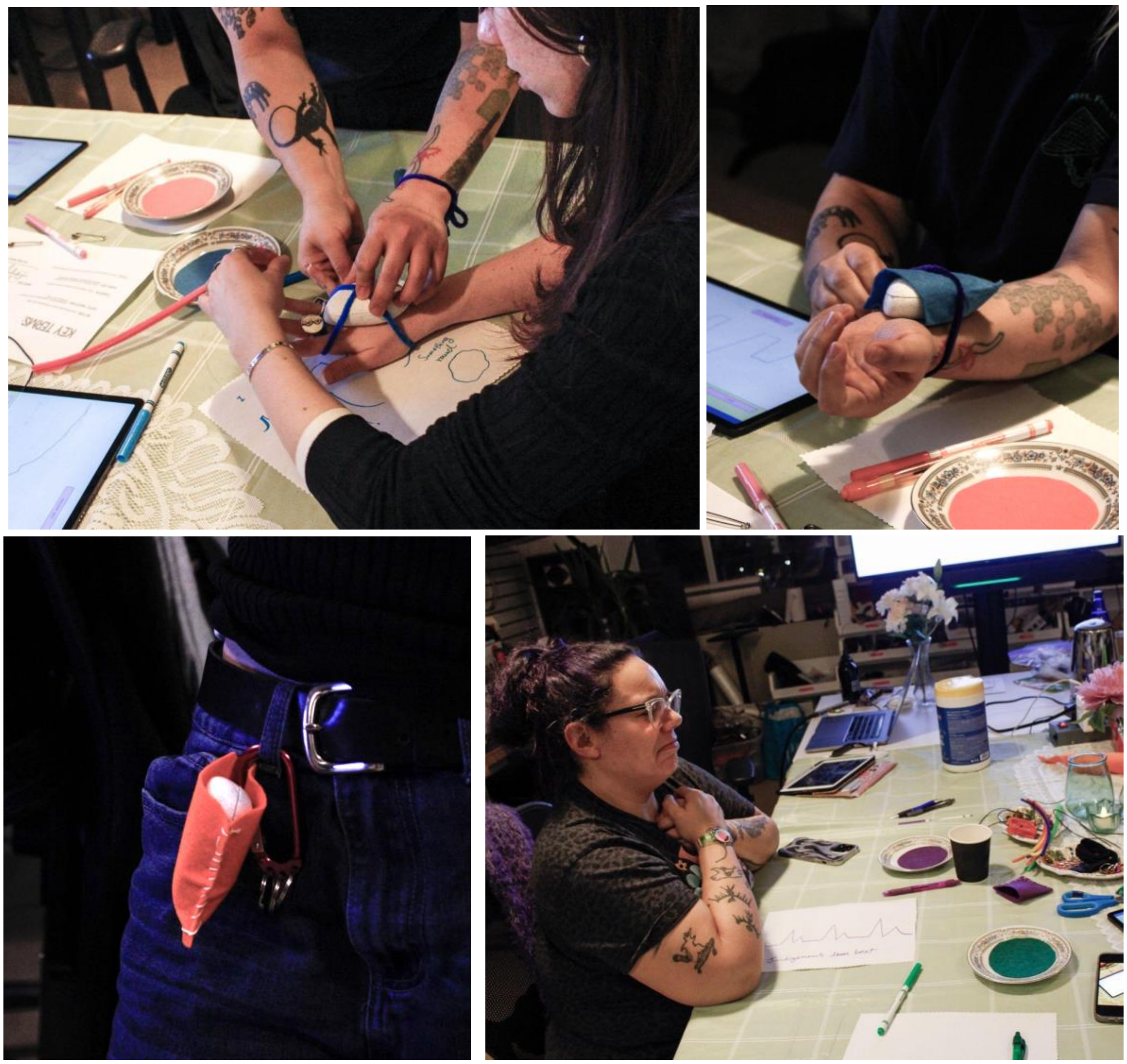

Figure 58: Participants exploring body placement and materials in the first workshop.

Figure 59: *Playing with body placement and materials in the second workshop.*

6.3.5 Collaboration Experience

Participants noted in the reflection period that the workshop setting was comfortable, and I observed an easy transition into facilitating the group once they had been invited to have a seat.

For the experience of collaboration, I had not expected that larger groups might have difficulty working together. In the larger group (four participants), it was hard to agree on a direction and participants found it confusing to know which tablet vibrations were coming from. Clarifying who was sending what messages were suggested to improve the collaboration experience, as having two tablets made it often unclear who sent what if both tried sending vibrations at the same time. However, participants built off each other's ideas, and the first workshop group had a positive creative experience with the collaboration aspect.

6.3.6 Usability in Daily Life

On whether they would use this kind of social haptic device in their everyday life, participant responses were mixed. Most participants saw the potential for discreet communication and the screen-free nature was appealing. The limitations in pattern precision and saving were large concerns for participants. Integration into existing devices, like phones, was of interest to some participants. Shared pattern vocabulary and agreed meanings were suggested as being an essential aspect of using the devices. A few participants also noted feeling overstimulated by the vibrations, but it is worth noting that the workshop was several hours long and there were about 30 minutes of near-constant vibrations during the “Make and Play” section.

6.4 Conclusion

It was a challenge to gather participants for a workshop series which specifically sought pre-existing friend groups, which limited the series to two sessions. Although the Haptics Tapas workshops informed the prototype development and the data collected contributes to the under-explored research area of group-based haptic communication, longer-term and repeated testing would offer valuable data regarding sustained usability in daily life.

Regardless, the data collected in the workshops contributed valuable insight into the discrepancy between visuals on a screen and felt vibrations, group dynamics in social haptics experiences, and meaning-making with vibration patterns. The wearability and usability in daily life considerations did not end up contributing to the final outcome of *Touchstones,* but are useful insights for further explorations in working with social haptic devices.

CHAPTER 7: CONCLUSION

7.1 Final Reflections

Touchstones began with an interest in the future of digital socialization and an ultimate desire to connect people socially – across distance, meaningfully, and in new and playful ways. Although the project evolved beyond the goal of distanced communication, *Touchstones* exists as a part of a larger discourse of how we socialize and what makes communication fulfilling when physical presence is not possible.

This work offers knowledge in designing tactile communication systems and multi-user haptic social experiences. Expanding upon the gaps identified in the **Literature Review** and **Related Works**, the Haptics Tapas workshops demonstrate that tactile communication in group contexts introduces unique challenges around authorship and creating shared meaning. Additionally, the GUI of the final few prototypes, a waveform drawing tool, was conceptually appealing to participants but did not reliably translate visual input into the intended felt experience. Evidently, haptic design tools benefit from embodied testing methods (Dourish 2001; Wittchen et al. 2025; Schneider et al. 2017). The physical form of the Touchstones also contributes insight into how material and aesthetic decisions can shape emotional resonance and social perception of haptic communication devices (Turkle 2007; Hassenzahl 2012).

Alongside the development of *Touchstones*, my design practice expanded from a primarily screen-based approach into an extensively material process of physical prototyping. Approaching the project from a graphic design background shaped both the opportunities and constraints of the work: while my experience with interface design informed the development of the GUI, working with haptics required designing in three dimensions and engaging with unfamiliar technical systems, particularly wireless communication across a network of devices.

As the system developed, the research focus shifted from facilitating communication at a distance to asking how friend groups construct shared meaning through personalized vibrotactile patterns, and what design conditions support that process. This shift was shaped both by the technical constraints encountered and by the outcomes of prototyping and workshops. While the project was initially motivated by experiences of social isolation during the COVID-19 pandemic, distance became secondary to the more central question of how something as ambiguous as a vibration can become socially meaningful.

Touchstones ultimately function as both a working prototype and a communicative probe for reflection and discussion (Sengers et al., 2005). Rather than proposing a fixed system of communication, it suggests tactile interaction as an open-ended medium through which social groups can develop their own shared forms of expression.

7.2 Future Work

Within the scope of this project, there were limitations to what was possible to achieve. Outlined in this section are areas for future research, both for myself and for others to expand upon.

7.2.1 Expanded User Testing

While the exploratory nature of this study was an inherent part of to the Research Through Design process, it also limited the extent of technical refinement and long-term deployment that could be accomplished within the project period. Future research could extend the workshops through additional sessions with a greater diversity of user groups, as well as through longitudinal studies of everyday use. Longer-term engagement would allow for a deeper understanding of how group or personalized tactile communication could be implemented in daily routines and change over time.

7.2.2 Additional Features

I had received several suggestions in both informal and formal testing for opportunities to expand the final prototype system which were not within scope to include in this study. Alternative methods of haptic pattern creation outside of the waveform drawing GUI included: audio recording to capture a pattern by either knocking on a surface, sounding out a pattern or recording a voice message and transforming this into a waveform of vibration intensity levels; using a pressure sensor on the haptic device for a user to physically tap or squeeze out and record a pattern; and using buttons on the device itself to add layers of interaction, such as sending out a specific preset pattern or “start” and “stop” recording buttons.

7.2.3 Communication Over Distance

In the future, expanding the system to support distanced communication is of interest, as was the original intent of this project. This would require a cloud-based network, as opposed to the local network I concluded with. Working with a cloud-based system would send messages over the internet, eliminating the physical router I used and allowing any amount of distance between devices. This would introduce new considerations for remote collaboration in the design of haptic patterns and asynchronous communication.

7.2.4 Software Only Approach

Expanding the system I designed for designing, sending, and receiving tactile communications into a purely software application is of interest for a future direction of this work. This would offer a wider reach in accessibility and potential adoption for group-based and personalized tactile communication. Mobile devices already support vibrotactile feedback in general and even enable custom vibration patterns – for example, IOS devices have a feature to “tap out” ringtone or notification patterns on the screen of mobile devices (“Change iPhone Sounds and Vibrations”). A future iteration could explore how tactile messaging might be integrated into existing communication platforms or developed as a standalone application which supports multi-user interaction and collaborative pattern design.

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APPENDICES

Appendix A: Haptics Tapas Workshop Materials

A.1 Facilitation Plan

Below is the full facilitation plan which was submitted to OCAD's Research Ethics Board (REB) for approval. This is the plan that I followed in hosting the workshops and was included here as it might offer insight for future explorations.

- **Welcome, Outcomes, and Itinerary** (15mins)
  - Introduce self and the intent of the workshop (part of a thesis project examining social applications of vibrotactile haptics and looking to see how haptics can augment communication over distance)
  - Explain goals and intended "learning" outcomes:
    - Learn (both I and the participants) about the potential emotional and communicative potential of various haptic patterns
    - Develop a shared and personalized haptic communication method for connection
  - Share schedule and timing with participants, as outlined in this facilitation plan
- **Intro to Haptics (**15mins**)**
  - What are haptics? What does vibrotactile mean? Review terminology and ensure everyone has the same base knowledge – framework of text buzzes and mobile applications for a point of reference
  - Everyone has a Touchstone device on their "plate", explain what is in front of them and how we will be programming them with a vibration pattern that has a communicative meaning between the participants' friend group
- **Tapas Time** (20mins)
  - Facilitation of small haptics tastings: I play 4 haptic patterns – pre-made – each consisting of 2-5 vibrations in length. Each "dish" (pattern) is based on a feeling or

phrase I had in mind, but is played for participants without a name to encourage them to guess at what it could mean. I share the waveforms of each pattern as a visual diagram on the screen so participants have a point of reference for the Brainstorm phase

- The patterns I presented were:
  - 1 (Poke) – two consecutive pulses, the second more intense
    - More of a literal approach as it is based in existing text tones, also based on a real gesture
  - 2 (Hold) – long pulsing
    - abstract as an idea of holding
  - 3 (How are you) – 3 consistent pulses
    - more literal but converting syllables into vibrations
  - 4 (Cheers) – lots of random varying intensity pulses
    - sparkling/fizzing sort of effect, meant as thank you, again more abstract approach to a real phrase
- After playing each pattern and asking “What does this remind you of (if anything)? What does it feel like?” I reveal the intended names and meanings of the vibration patterns
- Reflect:
  - Which patterns were of interest or stood out?
  - If you could send one of these to someone, who would it be and why?

- **Brainstorm** (30mins)
  - Now that there is a base library knowledge and thinking process has begun on how haptics could be applied, participants are encouraged to think on the following prompts and brainstorm collaboratively (drawing/writing materials provided):
    - *Part 1: Solo Brainstorm (5mins)*

        - Come up with ideas for what kind of communication you'd want to share with the group – this might be a feeling, a physical touch or gesture, a shared memory, a joke... the possibilities are endless!
        - Sketch, take notes, or just think about it.
        - What would you want to send to others?
      - *Part 2: Collective Planning (15-25mins)*
        - Let's come together to discuss our ideas & pick a direction for what communication, feeling, or meaning we want to collaborate on to turn into a vibration pattern!
        - What would your communication feel or look like as a pattern?
        - Sketch it as waveforms or lines, or even sound it out with "bzz bzzzz" to communicate the length, pattern, intensity of the vibration we want to create.
        - Visualize and ideate in whatever way makes sense to you!
  - Participants were encouraged to visualize vibration patterns in any way that made sense to them, to seek understanding of which approaches were useful
  - The end goal of this phase is to agree on a direction of intended meaning and design approach (waveform or other visualization sketches)
- **Break** (if needed, 5-10mins)
- **Make and Play** (45mins)
  - This section is broken down as follows:
    - Tutorial on the waveform drawing tool (5mins)
    - Explore the interface (5-10mins)
    - Turn our idea into a vibration pattern, iterating back and forth until satisfied with the result (10-20mins)
    - Body tapping exercise (2mins)
    - Play with materials and body location (10-15mins)

- Participants are first given an orientation on designing with the GUI, which takes in a series of points on the drawn waveform and emits them to all Touchstone devices
- Participants then have free reign to explore for a few minutes – the Make and Play phase is less strictly structured to allow for explorative play, but participants are guided into working on the pattern meaning they came up with and turning it into a felt vibration
    - Iteration is encouraged and supported, for participants to go back and forth in developing their pattern: Now that we are trying their proposed pattern, is that still what they want to create?
        - If they're good, what is working well? Feelings from it?
        - If they still want to play around, leave time for guided adjustments of their pattern – which parts do they feel do not work? What isn't communicating well?
- Once they have a pattern (or multiple) they're excited about, I phase them into a body tapping exercise as a warm up
    - Participants try tapping with fingers or palms on highlighted points or anywhere on the body, this is a tool used to stress relief and helps with feeling awake, and is a good way to orient with where might be interesting to try placing the Touchstone
- Participants then are given free reign to select from a sampling of various materials, including felt, safety pins, stretch elastic, pipe cleaners, and more, and encouraged to try different textural and wearable experiences with their Touchstone, while emitting their designed pattern
    - Guiding questions:
        - How does placing different materials on the Touchstone affect the experience of interaction?
        - How does placing the Touchstone on different areas of the body affect the experience of interaction?
        - If you had a pouch for your Touchstone anywhere on your body, where would you place it?

- **Share and Reflect** (20mins)
    - Prompt reflections addressed to the group on the experience as a whole:
        - What was the experience of using the tablet interface to design a waveform and sending out a signal?
        - What was the experience receiving a signal on your Touchstone?
        - What patterns did you come up with that you were most excited about?
        - How did it feel to work together to develop a pattern?
        - How might you see yourself using this kind of haptic communication in daily life?
    - The questions are designed to address many aspects of my project, covering material, form, wearability, interface, usability, sending and receiving, collaborating, and group dynamics

A.2 Recruitment Posters

Figure 60 demonstrates the posters designed for Haptics Tapas recruitment. 2 versions were designed: one version was made for email recruitment and another for print. Recruitment took place through OCAD University, through email and posters on the campus.

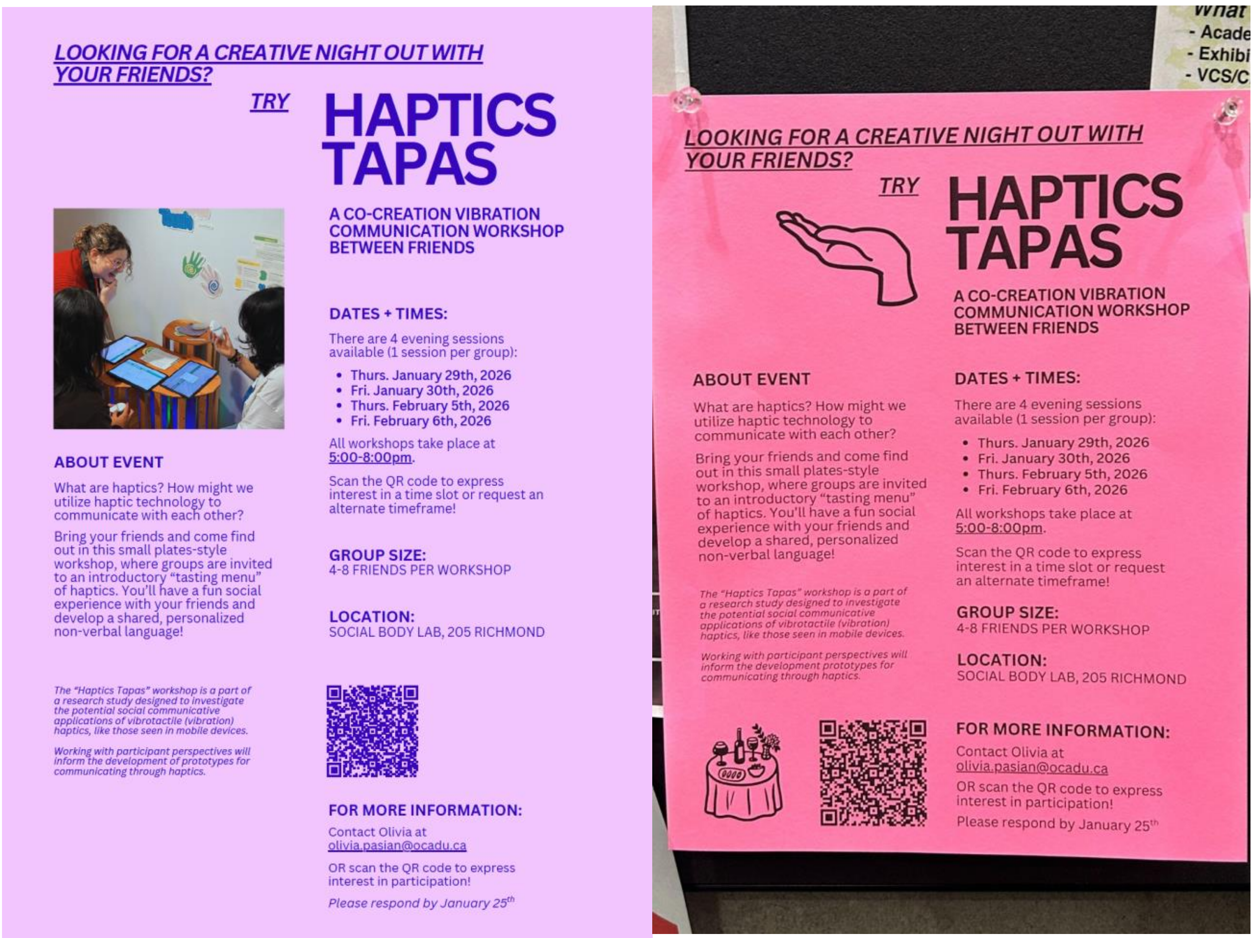

Figure 60: Posters designed for Haptics Tapas recruitment on OCAD University's campus. Digital poster (left) and printed poster (right).

A.3 Workshop Data

Reflection areas:	Group 1	Group 2
GUI	● Feedback on the GUI was generally positive, with participants noting its simplicity to use and the tactile, creative engagement it encouraged ● However, frustration began further into the process of working with the interface, as some found it challenging and confusing to precisely control waveform intensity due to the interface's sensitivity and limited intensity range (set more conservatively for the workshop specifically) ● Participants expressed a desire for features like saving and replaying their patterns (as they lost their original patterns every time they drew over them to try something new), looping functionality, and more intuitive and accurate controls to better reflect their designs as vibrations ● Participants noted an appreciation for the visual design of the interface, from an aesthetic standpoint	● Participants generally found the waveform pattern creator interface to be interesting in concept but challenging to use ○ The main frustrations centred around unpredictability and lack of precision when drawing vibration patterns ○ Suggestions included introducing snapping points or guides to help align pulses more evenly and visually demarcate time intervals (ex. marking 1-second and 2-second points within the 3-second maximum duration) ● Some alternative pattern creation / interaction tools suggested included: ○ Using knobs or sliders to adjust frequency, amplitude, and pulse duration, similar to audio synthesizer controls ○ Adding a "record" function to capture knocking rhythms or taps, allowing users to create patterns organically instead of

Reflection areas:	Group 1	Group 2
		manually drawing them ○ Simplifying pattern creation with preset waveforms (ex. sine wave) that users could then modify
Sending a signal	● Participants enjoyed the playful, and potentially secretive, aspects of sending personalized signals within the group, comparing it to “secret handshakes” ● Participants appreciated the live feedback and collaborative nature of designing signals ○ They generally enjoyed the design process, but as noted, had struggled with the GUI	● Due to the simultaneous sending and receiving of different patterns by multiple users, participants found it difficult to keep track of which pattern was currently being broadcast and who was controlling what, which made collaboration sometimes difficult ○ The ability to broadcast a signal to all participants at once was seen both as a feature and a limitation, dividing participants between the desire to send private messages and the experience of it being collaborative
Receiving a signal	● The tactile experience was sometimes disconnected from intended / expected meanings based on visual waveform representations, which caused surprises and many iterative adjustments	● Overstimulation or fatigue was noted after spending a notable amount of time with near-constant vibration ○ Participants found it harder to distinguish nuance in vibration as

Reflection areas:	Group 1	Group 2
	○ In the vintage vibration “tasting” portion, abstract intentions like “being held” or “a caring tap” felt alarm-like or urgent instead ● Participants noted how receiving signals could be an exciting and intimate way to communicate without words or gestures ○ The Touchstones discreet nature was appreciated for enabling subtle communication, it was compared to “kicking under the table” ● Phantom vibrations were discussed, noting how it’s possible to develop emotional attachments or anticipations toward these vibrations (as seen with phone vibration notifications)	a result ● Participants noted that the intensity, rhythm, and duration of vibrations conveyed different emotional tones or meanings, though some patterns were ambiguous ○ Simpler, more distinct patterns seemed easier to interpret
Pattern designs	● The pattern this group settled on was creating a heartbeat, with the intent to send a message of caring, love, or “thinking about you” ○ Other ideas included: ■ “Yo! Sup!” as two separated pulses, with a second between them ■ Squeezing hand as	● This group never settled on a single pattern, but ideas they considered and tested included: ○ Famous knocks, like Sheldon’s from the Big Bang Theory and the “shave and a haircut” rhythm ○ Cat ears (a pointed pulse with a curved

Reflection areas:	Group 1	Group 2
	a maintained intensity ■ "Yoohoo!" as a small pulse followed by a more intense vibration ■ An Indigenous drumbeat ● The participants were intrigued by the idea of non-linear patterns (ex. how could a circle be a vibration), discussion on representing shapes in a linear time-based vibration pattern	vibration before another pointed pulse) ○ S.O.S in morse code ○ A hug ○ Touching fur ○ A cat purr (heavy cat theme) ○ Bubbles ○ The feeling of being in water ● There was also discussion about creating libraries of standardized patterns to build a shared tactile language, which is one of the goals of the workshops
Collaboration experience	● The collaborative atmosphere was described as easy and comfortable in working with their friend group ● Participants were enthusiastic and openly contributed ideas, building upon each other's suggestions ● Participants noted that working with the device and patterns felt like a collective creative experience rather than a task, helping them feel more engaged and connected	● Participants enjoyed bouncing ideas off one another but found it difficult to coordinate input when multiple users were simultaneously designing or sending patterns ○ The shared interface created moments of disruption, which some saw as playful and part of the creative process, while others wished for clearer turn-taking or control mechanisms ○ There was some confusion about what pattern was playing when two were being sent at once

Reflection areas:	Group 1	Group 2
Wearability	• Participants tested the following placements of the Touchstone on their body: ◦ Chest (both clipped to and held) ◦ Strapped to inner arm / wrist ◦ Strapped to back of hand ◦ Attached to belt with a carabiner ◦ Held against ear • Participants had concerns about device stability during movement (several devices were dropped) and the comfort of certain placements (chest was very comforting and had emotional resonance, while the Touchstone did not offer much vibration feeling from being worn a belt carabiner)	• Participants tested the following placements of the Touchstone on their body: ◦ Dangling from the wrist using a carabiner and wristband ◦ Pinned to sleeve on upper arm ◦ Attached to a long cord around the neck ◦ Wrapped around forearm ◦ There was significant interest in the experience of placing the Touchstone on the top of the head, but participants found that it only had a noticeable vibration when under headphones or with hands over ears, to feel a vibration resonating • Some noted that wrist placement could be irritating, especially under winter jackets, while others preferred looser placements like the upper arm or a dangling attachment • Participants found it hard to feel vibrations at all if too many layers, sometimes even one layer if placed on a less-sensitive area (ex. upper arm) • Signals felt stronger and

<table>
<tr><th>Reflection areas:</th><th>Group 1</th><th>Group 2</th></tr>
<tr><td></td><td></td><td>clearer on more sensitive or direct contact points like the palm or chest compared to places like the head (without headphones)
● Interest in integrating the device with existing wearable tech like fitness bands or chest straps
○ A snap-fit attachment was suggested for the Touchstone</td></tr>
<tr><td>Materiality / form</td><td>● Participants enjoyed the 3D print material, noted the rippled texture of the filament layers – this was intentional design choice and was well-received
● The Touchstone form was also appreciated for being ergonomic & the thumb indentation was soothing
● Felt or soft textures like pipe cleaners enhanced patterns which were meant to be “caring” or “friendly”
● The natural form was said to help distance the device from being associated with other vibrating devices. It also helped to separate it from being clinical or overly technical in appearance, supporting the social / emotional use case</td><td>● Participants compared the shape of the Touchstones to well-used soap, but this was considered a positive feature due to the comfortable holding experience, described as ergonomic
● Participants were divided between enjoying the rippled/layered 3D print texture and wishing for a smoother texture
○ Suggestion made to explore other high-quality materials that might be able to replicate the look and feel of actual stone
● The form being based on an everyday object was considered a positive
○ Some participants proposed alternative everyday objects (ex.</td></tr>
</table>

Reflection areas:	Group 1	Group 2
		cups, other small household items) that could conceal haptic technology, allowing for secret or subtle communication ○ Participants seemed to see value in this being a household object rather than one to carry on their person ● Materiality discussion remained focused on the Touchstone itself, adding other materials on top of the device did not have a noted effect for this group
Usable in daily life?	● Participants were generally enthusiastic about the idea of integrating the Touchstones into everyday life ○ The concept of it being a kick under the table, a secret handshake, or emotional check-in were appealing to participants ○ Practical application of communicating across different floors in a small house without shouting was suggested ● The comforting, ergonomic, worry stone-like form had suggested potential as a	● Participants were overall less enthusiastic, compared to the first group, envisioning Touchstones or haptic communication as a part of their daily life – seen as more of a novelty at the current state ● Participants emphasized the necessity of establishing shared meaning/vocabulary and protocols for effective communication ● Many participants preferred the idea of integration into existing devices like phones or watches rather than carrying standalone objects, seem to prefer the idea of it being a desk object

Reflection areas:	Group 1	Group 2
	self-regulation or anxiety-relief tool ● Participants reiterated limitations in the current prototype (such as waveform precision and pattern saving) but were optimistic about iterative improvements ● Concerns were raised about the potential for haptic signals to cause anxiety or irritation if too demanding or intrusive	○ The use cases which were of the most interest to this group were desk-based notifications, discreet social signals, and emotional support ○ The device being screen-free was appealing

Table 6: Summary of my notes and insights from the audio transcription of both workshops.

Appendix B: Exhibition Posters

B.2 Prototype 1

Figure 61 shows the posters and display of Prototype 1 for the end of summer showcase for a course called Thinking Through Making.

Figure 61: *Prototype 1 posters for class exhibition.*

B.2 Prototype 2

Figures 62 & 63 show the posters designed for Prototype 2 displayed in a class exhibition with “how to use” instructions for the devices and contextual thesis information.

Figure 62: Digital posters for exhibiting Prototype 2.

Figure 63: Prototype 2 posters in exhibition set-up.

B.3 Prototype 3

Figures 64 & 65 show the posters designed for Prototype 3 displayed in a university program-wide exhibition with "how to use" instructions for the devices and contextual thesis information.

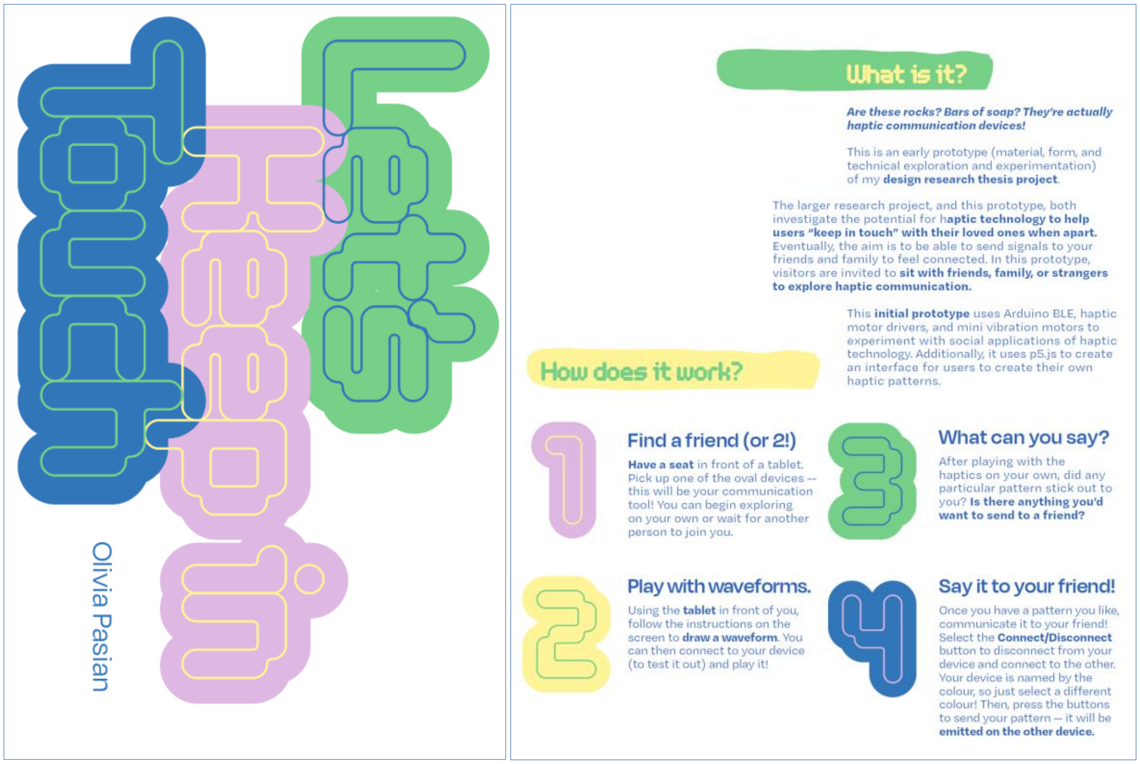

Figure 64: *Digital posters for exhibiting Prototype 3.*

Figure 65: *Prototype 3 posters in wall set-up.*