Making From Home

Reflections on Crafting Tangible Interfaces for Stay-at-home Living

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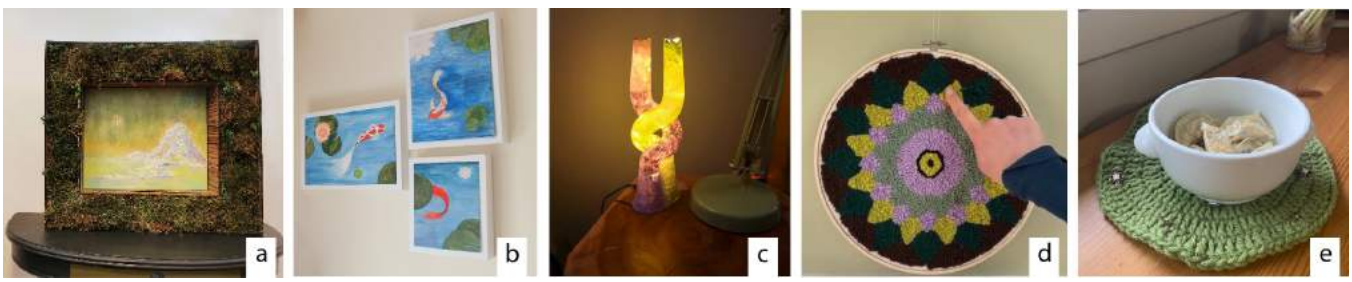

Figure 1: The five prototypes designed by the designing participants in the directed study on 'Homemade TUI': a) Liya, an olfactory frame to help connect with nature, b) Monaxiá, a series of colour-changing paintings to convey the loss of community connection, c) Connectivity-Candle that responds to movement near a connected and paired candle, d) Punch-Concert for ambient music playlists, and e) Party-Placemat for focusing on the experience of eating.

ABSTRACT

Pandemic lockdowns created new barriers for HCI researchers, but also provided new opportunities for deeper engagement and reflection in our home environments. Five participants were introduced with a design brief on self-isolation and engaged 12 of their friends and family in the design process of in-the-isolated-wild deployments. By analysing the design process, we found that –while 'making from home'– our participants noticed the subtlety of the interactions and materials, the processes of remembrance embedded in craft, the use of imperfection and metaphor in homeware, and how ambient presence can provide emotional support. We then conducted a follow-up study on the benefits and limitations of using a crafting approach while 'making from home' and discuss the tensions that novices experience while designing TUIs in such an environment. Our results expand the literature by highlighting the benefits, limitations, and trade-offs of user-led design, DIY user empowerment, and harnessing the power of craft.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

DIY, making, Tangible User Interfaces, home, artwork, design research

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1 INTRODUCTION

The COVID-19 pandemic caused major disruptions across industries, and especially in areas of life such as remote work and research. In our field of physical computing and tangible user interfaces (TUIs), the effects were especially pronounced due to having to design and study tangible artifacts in a virtual-only manner [3, 77]. Engaging people in tangible interface design pre-pandemic was already complex due to the multidisciplinary aspects that can make up such experiences [25]. The hands-on nature of tangible interfaces makes it even more difficult to practice from home.

The skills that are involved in TUI research are broad including topics such as digital fabrication, circuitry and Arduino, and user evaluation methods [25]. Engaging users in TUI design through hands-on making and crafting, such as e-textiles and paper circuits, can help to broaden participation, while enabling personalization and customization of computational devices [8, 33, 69, 76]. When the pandemic struck, researchers faced multiple challenges to quickly adapt these tangible, in-person experiences and exercises for online-only environments. Some of the earliest encounters (such as online physical computing courses) provided initial recommendations on what worked, and what didn't, so that as a community we could build off of each other's insights [2, 3, 77]. Other TUI publications during 2020 and 2021 (reporting new studies) relied on the lead researcher moving lab equipment to their home [12, 44, 53], arranging contactless drop-offs for prototypes [36], relying on non-physical methods such as speculation and design fiction [81], and collecting user input through remote interviews without in-person interaction [35]. Importantly, some of these adaptations and changes were so useful that they will continue beyond the pandemic, even into in-person settings [3, 77]. To further explore these issues our first research question is: **"What is the user experience of hand-crafting TUIs from home?"**.

The growing Do-it-Yourself (DIY) movement has been studied in HCI as a means beyond producing objects, but to also empower people in tech-making from children [53] and youth [41] to researchers [12] and occupational therapists [38, 51]. Despite the work done in this area to design and develop toolkits [7, 37] and kits-of-no-parts [49, 68], there is limited research to date on virtual making and the challenges of accessible training or educating others on physical prototyping or fabrication (such as in higher-education [2]). There is a research gap on how DIY, craft, and maker culture will catch up with the pressing need for maker activities to be at least partially shifted online. Moreover, prior work on DIY methods for prototyping predominantly focused on generating samples, swatches, or low-fidelity prototypes [75]. We need to examine ways we can truly empower people to move from ideas or swatches to independently crafting hi-fi functioning full-scale prototypes that are polished and robust enough to live with. By using *making* for critical inquiry, we can explore how this notion can be realized. By focusing on more open-ended crafting rather than kits we hope to explore what is both gained and lost when construction kits are used. This inquiry shapes our second research question: **"What are the benefits and limitations of a hand-crafted approach to making user-led TUIs from home?"**.

In this paper, we share reflections on living with and making TUIs from home with a focus on craft. This includes a qualitative study with 17 participants in 2 phases. The design and deployment of TUIs led by 5 of these participants documenting their TUI design process through autoethnography, and in-the-wild deployment of their prototypes in 7 households during a lockdown. Second, we conducted follow-up interviews with the 5 designing participants to understand the benefits and limitations of crafting TUIs in a remote context. This work is timely, as researchers are increasingly exploring, and struggling with, how to design with users who are not co-located in the same space and specifically how to design tangibles for real-world applications and for everyday use in their in-situ environment.

2 RELATED WORK

Our work builds upon research from four main areas: crafting meaningful experiences, tangible user interfaces for domestic use, TUI design from home, and online tutorials for making.

2.1 Crafting Meaningful Experiences

Tangible User Interfaces (TUIs) enable us to interact with devices like we would with everyday objects, but an area of tension is that they are often designed as gadget statements rather than resembling items that would normally be found around our homes or on our bodies [66]. This is true especially of DIY construction kits for designing with novices, which often prioritize usability with block-like components over user attachment and self-expression [45]. Prior work on tangible prototypes has also explored social activities and how textures [89], form [43], and sounds [60, 85, 86] impact individual and shared experiences. In user studies, participants have preferred aesthetic textile-based interactions for both wearables [18] and furniture [6] when compared to "screen-like" interfaces. In crafted technology, infusing personality into prototypes and matching the materials to the message are equally crucial to enable users to 'craft their identities' [18, 58, 73].

2.2 Tangible Interfaces For Domestic Use

Previous work on tangible domestic devices mostly falls within two areas: appliances and decorative furnishing elements. The first category includes home automation devices [29, 80] or appliances such as the Impatient Toaster [10], the slow juicer [28], the automated oven [87], and shower curtain display [21]. Automating home appliances has been explored to give them agency [10], and anthropomorphic qualities (e.g., the Thrifty Faucet [82]), or support religious practices [87]). The second category is furniture [6, 24, 50, 57] and decorative art.

There are several examples of of interactive furniture including the History Tablecloth [24], which illuminates decorative patterns on a tabletop using pressure sensors to capture the history of its use; and the matching peace painting and table [58] which change colour gradually to reflect the dual-cultural identity of some marginalized groups. Incorporating inclusive design in this sense is particularly valuable if we aim to challenge the norms of mainstream design practices. Many examples augment traditional decorative and homeware items with new capabilities such as the Photobox [63], Fenestra photo frame [84], ActuEater table cloth [52], transTexture lamp [89], and interactive stained glass [22]. In this paper, we leverage these blended embedded objects that we earlier coined as 'interioractive', a notion for interactive spaces that leverage interior design [56], and 'decoraction', which is "the merger of interior decoration with interaction design" [54].

2.3 Designing TUIs From Home

Tangible interface design and physical computing in virtual, remote settings became an important topic during the COVID-19 pandemic. Several recent HCI conference workshops and panels have aimed to create a discussion around how to engage people in physical computing virtually, demonstrating the depth of the problem, as well as the variety of approaches instructors have taken to address it [11, 67, 83]. Here, we summarize recent findings from three key recent publications on teaching the tangible skills of physical computing and digital fabrication during the pandemic [2, 3, 77]. To address the lack of a lab space or maker space, most researchers/educators developed kits to send out to individuals [2, 3, 77]. These were either created and sent out by the academics [3, 77] or created as a purchase list where individuals had to order and obtain their own tools and materials [2]. One of the limitations of sending out kits is that participants living internationally experienced delays in receiving materials, with some individuals not receiving their materials until the last week [77]. Without equal access to lab tools, virtual engagement can widen people's inequities [2]. To compensate for this, some experiences focused on virtual simulation of tangible components, for example using TinkerCad to simulate Arduino systems [77], or using CAD software to simulate fabrication [2]. Team communication can also be difficult in virtual-only environments, especially when trying to convey tangible subject matter. This made it harder for groups to integrate projects (i.e. to bring together their individual work into one whole) [3], as well as missing the ambient awareness of what other team members are working on when not physically working side by side [77]. Virtual courses also required a higher workload from researchers by, for example, printing out participants' design files, shipping materials to individuals [2]. Encouraging peer-to-peer support could help to alleviate some of these pressures [2]. Having making tools at home (whether through mailed kits or purchase lists) helped to support more iteration and the ability to work at flexible times based on the participants' schedules [2].

2.4 Online Tools and Tutorials For Making

HCI researchers, even before the pandemic, have been exploring making tutorials through virtual means, with the aim of enabling users to scale beyond physical in-person experiences as well as for at-home and DIY learning. Increasingly, individuals are able to learn DIY skills virtually and create their own interfaces through online tools and resources, such as maker tutorials on Instructables or Ravelry [9, 42, 65], as well as through video platforms such as Youtube and live streaming platforms like Twitch [20]. For example, creators are increasingly using overhead cameras for virtual crafting tutorials, an approach that will continue to be used after returning to in-person [35]. Researchers are increasingly exploring what is the best medium for providing tutorials for tangible and tacit skillsets [19]. For physical computing, iteration and debugging designs is especially important, with programs such as AutoFritz [47] to help support virtual circuit simulations with autocomplete features, hybrid platforms like PPCards [27] or tools that recognize issues such as Aesthetic Electronics [46] for hybrid crafts, or projected assistance such as BodyStylus[74]. To introduce novices to physical computing, researchers have explored using beginner friendly boards such as the Circuit Playground Express for wearables [30], BBC MicroBit with its built-in sensors and LEDs [1], or using material exploration with dyes and polymerization for quickly developing experience prototypes [32, 79]. For teaching individuals the tacit skills involved in hybrid crafting, researchers have explored printing instructions on the medium of the tutorial [36], as well as providing augmented tools for error correction [59].

3 RESEARCH CONTEXT: DIRECTED STUDY ON HOMEMADE TUI

Five participants, learning physical computing for the first time, were involved in a directed study on 'Homemade TUI' during the pandemic. The goal of the project was to learn how to create tangible interfaces for the home with a focus on craft, as well as going through the user centred design cycle phases of ideation, prototyping, and evaluation. Each of these five designing participants are also co-authors in this paper, a common practice in autoethnography and craft research in HCI for acknowledging maker participants as collaborators [13, 17, 23, 48]. The context of the directed study allowed individuals from a wide variety of backgrounds to participate, and also provided a living laboratory for exploring how we can engage users in physical computing, as well as the benefits and limitations of using a hand-crafted approach to the topic. Each designing participant went through the entire cycle while at home during pandemic lockdowns and evaluated their prototypes with their friends, family, and roommates. Our results include their autoethnography notes, transcripts from their individual studies, and post-deployment follow-up interviews.

This research project addresses two key questions:

- ***RQ1***: What is the user experience of hand-crafting TUIs from home?
- ***RQ2***: What are the benefits and limitations of a hand-crafted approach to making user-led TUIs from home?

3.1 Participants

Our five designing participants were involved in authoethnography reflections while making, and recruited those in their households (friends, family, roommates) for their individual studies. Our five designing participants (all female; age-group: 20-30) were university students in the field of computing with an interest and passion for art or product design, and for who this project would provide their first experience with physical computing. Designing participants were diverse in terms of cultural backgrounds, where two originated from East Asia, two from North America, and one from Africa. The designing participants also helped recruit 12 participants from their immediate circles (6 Female, 6 Male). In this paper, we refer to participants as P1 to P17 for anonymity. Table 1 shows the relationship between the 5 designing participants and 12 participants in the five user studies they ran.

Table 1: The five prototyping studies with 5 designing participants and 12 other participants in 7 households.

Prototype	Designer	Participants	Deployed Household
Liya	P1 (F)	P6 (1M)	H1 (P1+P6): housemates
Monaxiá	P2 (F)	–	H2 (P2)
Connectivity-Candle	P3 (F)	P12~P14(2M, 1F)	H3 (P14), H4 (P3): mother and daughter
Punch-Concert	P4 (F)	P7~P11 (2M, 3F)	H5 (P7+P8), H6 (P9+P10): 2 couples are friends
Party-Placemat	P5 (F)	P15~P17 (1M, 2F)	H7 (P5)

3.2 Methods, Procedure, and Data Collection

To answer our research questions, we ran a two-part study.

3.2.1 Part 1: Design and Deployment Study. To explore the in-situ potentials of designing and deploying these prototypes in-the-wild, we used autobiographical design [16, 61] as a methodology to reflect on the lived experience with the designed prototypes, and to better understand how designers might want to customize them. Autobiographical design research draws on extensive genuine usage by the designer of the system [61], including key features such as genuine need, fast tinkering, record keeping, and long-term usage [15]. Each designing participant also ran a user study interview with their friends, family members, or roommates to better understand how others experienced living with the prototypes.

This project was entirely executed from home. Each designing participant recruited other participants from their immediate circles and ran all the interviews via voice/video conferencing (using MS-Teams and Zoom). Each designing participant was working alone from their home during a stay-at-home order lockdown without ever meeting any of the others in-person. In-situ studies were carried out with family members or individuals of the same bubble, or using contactless delivery, to adhere to all COVID-19 restrictions enforced by our academic institution and local authorities. Prototypes were posted or dropped off at participants' houses followed by a virtual meeting. Participants were encouraged to share their thoughts or correspondence with others regarding the prototypes through texting, audio-recording or forwarding anonymized screenshots of chats.

Due to the flexibility of directed studies, designing participants did some research beyond the examples from the literature that they were provided with. Although the course of this project was planned over a 4-month period, our participants spent approximately 6-7 months on their respective projects. During this period, the participants and their family members, roommates or distant loved ones designed, built, and lived with these tangible interfaces. The data collection for this section included the autoethnography notes of each designing participant, and the transcripts of their study interviews.

3.2.2 Part 2: Follow-Up Interviews on Project Reflections. To better understand the benefits and limitations of using a hand-crafted approach for user-led design of TUIs in a remote setting, the first author (not involved in the design process), did a follow-up interview with each of the five designing participants. This semi-structured interview, conducted through Zoom, included questions on their making and evaluation process as well as their recommendations on how we should run similar projects in the future. The main topics included:

(1) The overall journey of their project and how they divided their time,
(2) How they sourced materials for this project and any barriers they came across in doing so,
(3) The prototyping process as well as any potential benefits or limitations of prototyping from home,
(4) The communication channels used to interact with others during the project, to interact with their study participants, and to interact with the rest of the research team, and any potential benefits or limitations of each,
(5) Their prototype evaluation process, and any potential benefits or limitations of doing so from home, and
(6) Recommendations for future iterations of similar projects.

Their answers were collected using Zoom transcription, and anonymized for analysis.

3.3 Analysis

Our study produced five different prototypes, each built by one of the five designing participants. P1 created a visual and olfactory piece of wall art called Liya; P2 created series of connected artworks called Monaxiá; P3 a connected pair of candles called the Connectivity-Candle, P4 created musical wall art called the Punch-Concert, and P5 created a pressure-sensing Party-Placemat.

We captured qualitative data consisting of designing participants' auto-ethnographic notes, sketches, and photographs in addition to audio-recorded remote interviews with participants (through video or voice calls), chat excerpts, and field notes. The video calls were transcribed and then all notes and transcripts were analyzed using MAXQDA [26]. The first author (not involved in the design process) performed reflexive and inductive thematic analysis as described by Braun et al. [4, 5] that emphasizes the active role of the researcher in meaning making rather than around a previous framework or set codebook [5]. This involved reading through the transcripts in MAXQDA with initial notetaking, and then line-by-line iterative semantic coding that aimed to emulate the language our participants used. With this initial list of codes the first author then grouped them using a Miro online whiteboard into central organizing concepts, with themes and subthemes to create a thematic map. This analysis method was used for Part 1 to analyse the documents produced from the design process, and for Part 2 for the follow-up interviews.

Figure 2: The design process for Liya by P1: a) Developing the design concept; b) Combining both the Chinese brushing technique and the impasto knifing technique of hand-painting; c) Experimenting with thermochromic pigments and mixing them with painting oils; d) Mixing a dozen of essential oils to generate the daytime and nighttime scents; e) Laser-cutting the frame and implementing the circuit that actuates the colour-change and olfactory feedback; f) Final touches (adding the moss) and testing the Arduino-controlled diffusers.

4 CRAFTED PROTOTYPES

4.1 Liya

The interactive wall-art li-ya (离压), which means 'out of stress' in Mandarin, was designed by P1 to recreate and simulate the outdoors through visual and olfactory interactions and to *"provide a multi-sensory experience"* (P1), see Figure 2. The painting shows an outdoor scene with mountains, rivers, and bridges, that change using thermochromic pigments to signify the passage of time. Using an Arduino Uno and heating pads hidden behind the painting, the colours shift in tone between warm and cold to correspond with the shift from day and night. For example, fiery orange pigments during the day becoming subtle yellows when heated in the evening.

P1 created the olfactory experience with two DIY scent diffusers (created by "hacking" commercial products to work with the Arduino Uno). After prototyping a variety of smell combinations, P1 chose an uplifting scent for during the day (a mild, minty aroma that faded to a light evergreen scent), and a crisp scent for during the night (a combination of Rain Forest, Japanese Cypress, Balsam Fir, and spearmint).

During the 12-week deployment in H1, the two housemates (P1 and P6) decided to place Liya in their living room "*where we [share] having dinner or watching movies*" (P1). Participants noted that Liya did not dramatically change their experience but it has helped bring them together to share free time, conversations, and meals together where Liya "*brings a little bit of colour to the living space. Now when we have dinner, it's like we have a specific topic to talk about*" (P1). Despite designing Liya to support the connection between the isolated individual and the outdoor environment, it actually supported the togetherness and social engagement between the two housemates and became a reminder "*to actually sit down together and like trying to feel [Liya ('out of stress')] a little bit*" (P1).

4.2 Monaxiá

'Monaxiá', referencing the Greek term used to signify loneliness, was designed by P2 as three pieces of interactive wall-art that are meant to reflect the isolation experienced during lockdowns (see Figure 3). The three canvases were placed beside each other and communicated wirelessly. Touching one of the canvases would randomly change another artwork's appearance through thermochromic colour-change of the fish and flowers. The capacitive sensors (made with aluminum foil) when touched would signal to one of the other wi-fi modules. Once received, the heating pad would turn off, allowing the thermochromic paints to cool down and change from brightly vibrant colours to more faded ones.

The artworks had several interactive elements. Two paintings include colour-changing flowers that change their colours from white to pink to red as they shy away from an observer. In the first artwork a fish distances itself from the observer by diving deeper underwater. In the second artwork a koi fish turns from bright red to matte black upon interaction. The bright red colour is a signal of vibrant energy that is not, however, shared with strangers. The third artwork has a koi fish that changes its pattern i.e. changes its type to form another identity.

Interactions with the prototype aim to create a sense of connection with oneself. Each koi fish is isolated and separated from its surrounding environment, yet yearning and longing for communication. Placing it in her household allowed P2 to visualize and reflect on these emotions, as the colour changing koi fish and flowers slowly transition to darker or lighter shades.

4.3 The Connectivity Candle

P3 designed a pair of digital candles that would connect the dining rooms of distant loved ones (see Figure 4). P3 made the intertwined candles by experimenting with their family's domestic 3D-printer

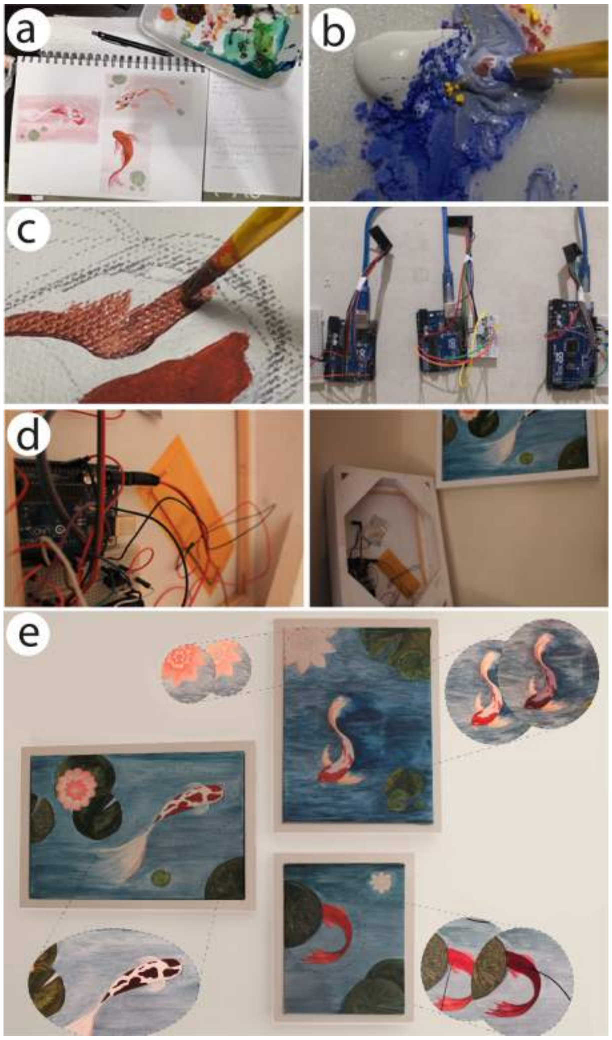

Figure 3: The design process of Monaxiá by P2: a) Developing the design concept; b) Experimenting with mixing acrylic paints with thermochromic colour-changing pigments; c) Crafting the paintings on canvases that conceal the Arduino-controlled circuit in the back; d) Implementing three separate battery-powered circuits that wirelessly trigger each others' heating pads to activate the thermochromic paint with capacitive touch sensing; e) Final touches and testing the interaction that reflects hidden metaphors.

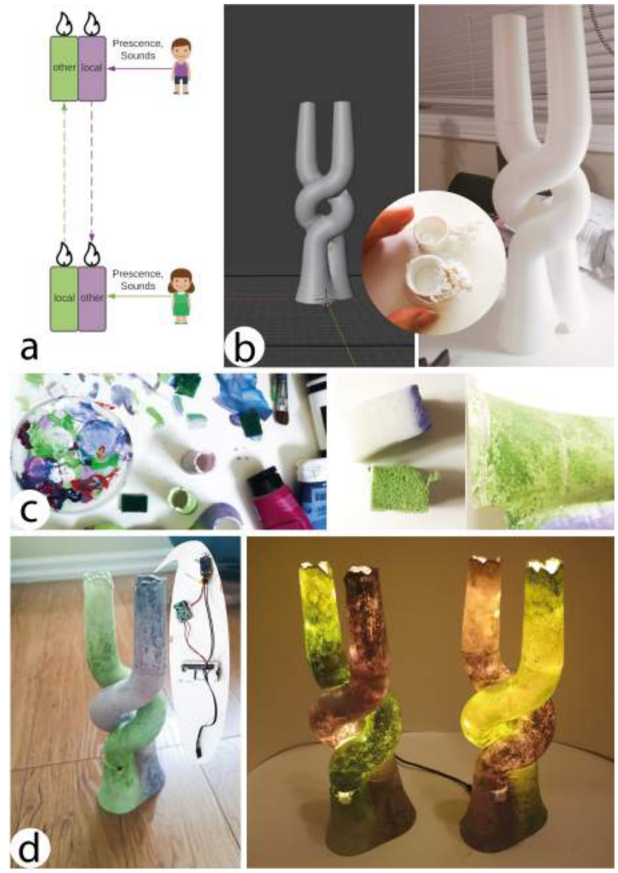

Figure 4: The design process of the Connectivity Candle by P3: a) Developing the design concept of two remotely-connected candles; b) Designing and 3D printing the candles with white filament and a hollow body through several failed trials; c) Painting the candles with brushes, sponges, as well as melting parts for tactile texture; d) Implementing the circuit with proximity and sound sensors.

(CR-10) and basic white PLA filament. To add colour and texture to the final print, and to filter the light, P3 used acrylic paints, brushes, and sponges. Inside the candle structure there was a Raspberry Pi Zero with LED string wire lights, LED current converters, and a sound sensor and infrared sensor to record presence.

The Connectivity Candle pair were each located in a different city, one in H4's (P3) apartment dining room, while the other was placed in the dining room of H3's (P14) family home approximately 300KM away, over a four week period. The design of the piece functioned as home décor and hid all signs of hardware that might detract from the dining experience. The piece created another avenue of social engagement beyond other forms of contact such as phone calls, offering a sense of presence and connectivity without demanding constant focus.

The candle increased mutual reciprocity in the relationship. On one hand, participants expressed unexpected feelings of anticipation when they started eating as they subconsciously expected the other candle prong to light up. On the other hand, when participants saw that the remote candle had lit up, they were motivated to enter the dining space and begin eating.

4.4 The Punch Concert

P4 designed a pair of e-textile punch-needle art pieces, each to be wall-mounted in the homes of distanced loved ones (see Figure 5). The two Punch Concerts were designed to support capacitive sensing and audio feedback of connected music playlists. The pattern design included the circular shape of a musical record with floral

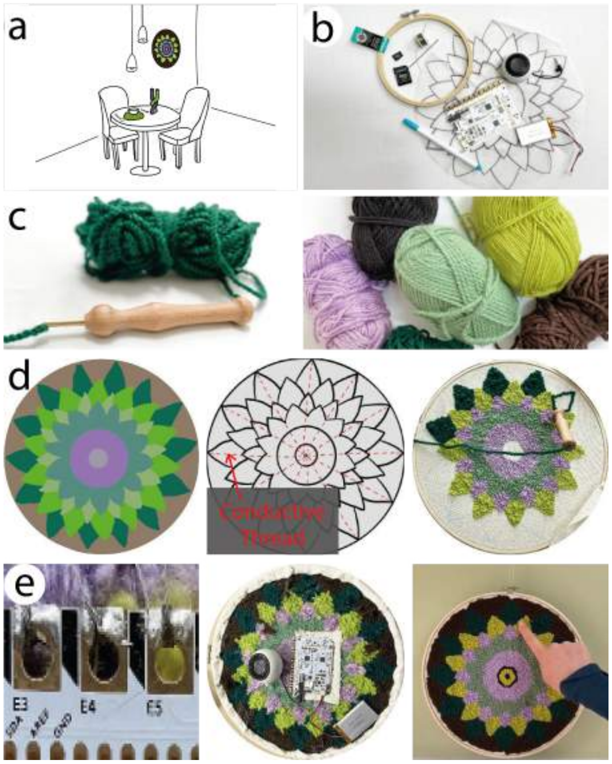

Figure 5: The design process of the Punch Concert by P4: a) Developing the design concept of a pair of wall-art pieces; b) Designing and sketching the outline on a 12" embroidery hoop; c) Using a punch-needle and a collection of wool yarn; d) Designing and crafting the pattern as a digital illustration, then on parchment paper, then on monk's cloth to punch the wool and conductive thread; and e) Implementing the battery-powered circuit with capacitive sensing and audio feedback, and concealing it in the back for a seamless interaction experience.

colours. Through sketching different patterns and tracing potential designs on parchment paper, P4 settled on the final design before transferring it to monk's cloth on a 12-inch punch needle hoop. P4 explained her design process with aesthetic details such as: *"I filled in the design using varying colours and thicknesses of wool, such as chunky wool in dark brown, then sewed in conductive thread into the design and hot glued the ends to prevent fraying"*.

The Punch Concert was studied in-situ across two groups over a two-week period. Group A consisted of two professional musicians (P7:F, P8:M) in H5. Group B consisted of a married couple (P9:F, P10:M) with backgrounds in public service in H6. The two groups are neighbours in an attached building but have been physically distancing from each other during lockdowns. Throughout the deployment the two groups logged daily updates through text messages. A post-study interview was then conducted and transcribed for analysis. Participants described their overall experiences as *"pleasant"* (P7), *"insightful"* (P8), and *"nostalgic"* (P9 and P10). The pieces were seen as conversation starters, *"it gives external stimulation to help the conversation flow, putting less pressure on the people"* (P7). The *"music became a part of the conversation versus just being in the background"* (P9).

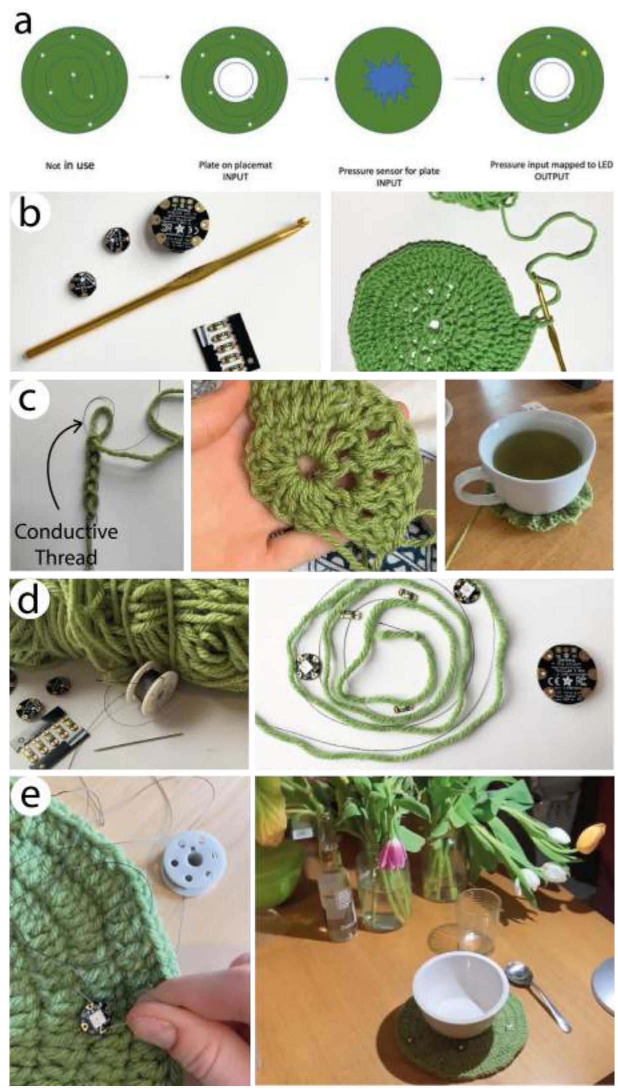

Figure 6: The process of the Party Placemat by P5: a) Developing the design concept of hand-crafted coaster or circular placemat; b) Selecting the tools, materials, and crafting method; c) Learning to crochet with both wool yarn and stainless steel conductive thread; d) Embedding sewable LEDs and an Adafruit Gemma microcontroller in the final design; and e) Implementing the pressure-sensing circuit with conductive thread and LEDs.

4.5 The Party Placemat

The Party Placemat was a pressure-sensing placemat that P5 designed to light up when tableware was placed on top (see Figure 6). P5 was inspired by a few home decor items from one of her interviews where a participant showed a round handwoven straw trivet and a crocheted tea vessel handle. The design developed into a crocheted circular placemat using earth tones and green yarn. P5 learned how to crochet a granny circle by watching Youtube tutorials, and with a 5mm crochet hook was eventually able to produce the intended design that: "*has a cozy home look*" (P5). The e-textile components were sewn in afterwards.

The Party Placemat was used by P5 as a place setting for casual weekday dinners. The original plan was to have a dinner party and observe how guests interact with the prototype. Due to changing COVID-19 restrictions, this could not be done and autoethnography was used solely. P5 frequently set the placemat up at the kitchen table in H7 for solo meals where reflective notes were taken after dinner had concluded. P5 felt that the placemat was unintrusive in the dining environment and added a level of formality and purpose to the meal. During her meals with the interactive placemat, P5 felt it is like *"a dinner party for one*" and expressed that: *"It created the feeling that dinner was an experience, and not simply something that had to be done*".

5 FINDINGS PART 1: USER-LED DESIGN AND DEPLOYMENT RESULTS

The first author analysed the designing participants' authoethnographic journals and transcriptions from their user studies to better understand the process of making from home and living with their interactive objects. These included recognizing subtleties in the interactions and materials over prolonged use, how crafting and their crafted prototypes encouraged remembrance, the importance of tactility, the use of imperfection and metaphor in home goods, and how unspoken communication can provide support.

5.1 Subtle Discovery Through Making

Living with their designed objects helped our participants to notice the subtleties of the interaction. These included the material subtleties, such as the way the Connectivity candles "*flicker*" (P3) in different lighting conditions and depending on the time of day. Participants also began to notice the subtleties of the sensors used and how they responded differently in different spaces. For example, one participant noticed how at times their tangible objects would turn on when they entered the room rather than just when they were at the table. During use they began to notice how their designed things interacted with the other objects in their home. For example, how the interactive Party Placemat also lit up their tableware and gave their food a nice glow, while also signaling for the meal to begin.

Living with their objects enabled our participants to notice these more subtle interactions and test and tweak their prototypes continuously. This occurred while they were crafting the objects, for example with the Party Placemat our participant tried out their prototype while in the process of crocheting it – trying it as a coaster, then expanding it to a placemat. Our participants explored whether their prototypes fit within their space, using them while they were still unfinished. This included informal feedback sessions with housemates along the way. Our participants discussed asking their housemates for feedback while they were testing them in place, and sending photos to family members to ensure they were "*on the right track*" (P5).

Living with their prototypes helped our participants to also confront the potential "*dark patterns*" of the objects they had designed in ways they did not initially consider. For example, with connected prototypes our participants highlighted potential "*data monitoring concerns*" (P3) that would be worrisome if someone other than their trusted family members had access to the objects. Having their prototypes within their home also encouraged them to reflect on the technology infrastructures that were already there – such as connecting their system to the family Spotify account.

5.2 Tangible Remembrance

Our participants enjoyed combining crafting techniques with physical computing. Compared to other work tasks they found the crafting process to be "*reflective*" (P4) and helped them to be "*more present*" (P5). Crafting was a way to remember and document the passing of time. Our participants commented on how their crafted objects reminded them of individuals: "*made me think of my Granny and my Nana*" (P5), or how the ambient sound caused group reflections of trips and memories pre-pandemic: "*It definitely made us think of travel and we talked a lot about travel I think almost every time we turn it on. [It] brought back happy memories of things we'd like to do.*" (P10)

While working on this project, our participants increasingly recognized how often physical objects within their homes helped to make space and time for eating. For example, the rituals of setting the table, having a specific location to eat each meal, and washing up at the end. These objects and rituals gave each meal "*a very definitive start and end*" (P5) that helped them to make time for eating, rather than trying to hyper-productively combine eating with other tasks. Similarly, living with the prototypes encouraged individuals to make this time just through their presence, and caused them to "*reprogram [their] eating habits*" (P7). At first, they had to actively remind themselves to make this space, but with continued use of the prototypes it became second nature. "*I would say once we got used to it, we were quick to turn it on. Before, we would sit down, start eating, and we'd [have to] think about it more often"* (P8). Many participants reflected how in their day-to-day lives they do not normally create this space for eating, and saw this as a benefit of living with the prototypes.

Along with being physical reminders, they also cued more direct communication. For example, a prototype's interactions or changes often became a conversation starter between individuals in a shared space. Each prototype became a "*conversation piece*" (P9) that our participants thought would be useful in "*group settings*" (P10). Interactive homeware also became a reminder to directly communicate with the individual or family who had the connected pair. For example, seeing the connected candle turn on at unexpected times "*made me wonder what the other side is doing*" (P3). One participant "*noticed that [their family member] is having extremely late dinners and had a conversation with her about stress and health*" (P14). Seeing changes in a loved one's habits often resulted in them reaching out directly to check in with their family member. But even though this was the catalyst for the conversation, family members would go on to discuss other topics such as sharing what happened that day.

5.3 Importance of Tactility and Crafted Interactions

Participants brought up the "*screen fatigue*" (P4) that they felt especially during the pandemic where communication was often limited to digital devices; "*I'm super sick of looking at screens all day because I'm on them nonstop*" (P10). In contrast "*communicating with the prototypes through touch emphasizes the tangible interaction we are all missing during this time*" (P2). Our participants reflected on the tactile nature of most non-digital devices within their homes. They also discussed how tangible interaction was more direct: "*It was less effort so that was nice. We just turn around and press the leaf and then you're done so I think it's a timesaver*" (P9).

Our participants often used metaphors in their designs to help blend their interactive objects into the home environment. For example, with Monaxiá the prototype resembled a piece of wall art, and with the Connectivity Candle they looked like centerpiece candles. Aesthetic metaphor often took precedence over usability. For example, our participants understood how to use the interactive objects, but someone first approaching them might not. Participants also enjoyed seeing "*the hand*" of the maker in the prototypes: "*I love that there's a handmade aspect to it*" (P5). This was presented in the materials and techniques used such as the use of crochet, which provided "*warmth, comfort and familiarity*" (P5).

5.4 Care and Comfort Through Ambient Presence

The interactive homeware provided the "*presence*" (P3) of a friend or relative and associated feelings of comfort and support. "*I think when people first get to know each other, verbal communication is important, and later on it seems less important, such as my relationship with my best friend. I tell her the most private and secret events of my life, but we sometimes do not contact each other for months. This is the same with my family.*" The interactive homeware helped individuals feel "*connected to my family without the pressure of talking*" (P3). Seeing an individual's presence through the tangible objects helped individuals express care without having to look "*presentable*" – "*you don't have to be dressed [and on screen] but you can still be connecting*" (P7). It gave them an ambient awareness of their family members without having to directly reach out – "*it's kind of nice like 'oh [family member] is eating dinner too right now'*" (P8).

The ambient presence of a loved one also complimented other forms of on-screen interaction. Rather than replacing screens completely they added another element to the conversation. "*I feel like there is some warmth missing in remote connection, but the candle makes up for it. The moment both lights flicker on, I feel cared about*" (P3). Because these interactions occurred throughout the day, they also provided continual support, "*a constant sense of presence, unlike calling my parents, which is always shorter*" (P3). The interactive homeware helped individuals feel included in their family while separated from them – "*just knowing that somebody was including me, inviting me, thinking of me, I feel like that would be really nice*" (P7). Participants also felt comfort when listening to ambient or recorded sounds, such as those that emulated the hustle and bustle of cafes, to emulate the physical presence of others. This demonstrated that there didn't always need to be a physical person at the other end to feel the comfort of emulated physical presence. "*I really liked the atmospheric [sounds] where you could hear other people in a restaurant*" (P8).

6 FINDINGS PART 2: FOLLOW-UP PROJECT REFLECTIONS

After the in-situ studies, the first author interviewed each of the designing participants to better understand the benefits and limitations of making tangible interfaces from home. In our follow-up interviews, we found how participants dealt with ordering their materials, how participants focused on crafting before computing, tensions between custom and shared infrastructures, and the benefits and limitations of virtual communication for physical computing.

6.1 Pre-Planning for Wait Times

Our participants went through several pre-planning steps to prepare for their making at-home projects, and their few months of intensive making and evaluation. For individuals first learning physical computing, understanding what can be feasible to build within a set timeframe can be challenging. For example, P1 mentioned that *"I really want to do very cool stuff, but that might not be very realistic to implement within like four months, or within a period of time"*. This is normal for novices to physical computing and was a sentiment shared across the participants: *"There were times where we were very unsure about if what we wanted to do was feasible or not"* (P3). As a result, an important pre-step was understanding whether their project was achievable and researching tutorials before deciding what items to order: *" I think have the [participants] think it through, and make sure they have everything they need before they go and order it"* (P4).

6.1.1 Time needed for supply chain wait times. To support their projects our participants had to order specific supplies, and rather than picking up items at the lab, they had to have everything shipped to their homes. As a result, more time was needed due to supply chain wait times. Participants had to plan *"what kind of materials we needed, any prep we needed, and also getting materials delivered*" (P3). This had an impact on iteration – for example, having *"to wait a little bit to order stuff and wait for it to come back*" (P3). By planning out their requirements early on they were able to iterate on ideas based on their practicality – for example, knowing that certain items would not arrive on time. This feeling was summarized by P1: *"[a specific actuator] was going to take forever to ship here, and it's so expensive as well [so] I just didn't end up using it*". Lead times were often long, resulting in participants having to focus on other parts of their project: *"I think if I had access to the research lab, I think it would have been much easier, and I would have found everything I wanted within a day instead of a month*" (P2).

6.2 Crafting Before Computing

6.2.1 Crafting first. In contrast to previous work in design, where physical computing prototypes are developed first before considering the craft or aesthetics of the device, our participants used the opposite approach. They crafted their prototypes and engaged in creative prototyping activities first before adding in physical computing components and engaging in technical prototyping. For example P5 wanted their device to have *"a very homey, cozy vibe with crochet [because] I thought that people can be kind of apprehensive with visible technology."* Crafting was found to be more accessible than physical computing and helped them to figure out what they needed before ordering components. Participants either had supplies at home, or were able to easily access local craft stores during this time. For example P4: *"got some supplies at a craft store, and then I just watched some videos, and I did a little practice piece before doing [the final version]."*

6.2.2 Craft materials were more readily available. Due to the constraints of working from home, working on a craft of their choice enabled individuals to use crafting materials that were more readily available. *"It was so much easier to experiment because I had access [...] I had more materials, and also I knew that if I needed more, yarn is a lot easier to get"* (P5). This enabled participants to leverage their interests, past skills, and *"just use what I had before"* (P1) such as paint and yarn, as well as accessible tools such as paint brushes and needles, and figure out the design of their device while waiting on other materials to arrive. *"For those materials, luckily I already had them, because I'm a hobbyist. I really like drawing and painting. So for these materials it wasn't a challenge because I had them already compared to the Arduino and the electronics - I didn't have them at home"* (P2).

6.2.3 Crafting from home supported iteration. One of the main benefits of crafting from home is that it supported iteration. Participants had more control over their making environment. For example, they could leave out their paints to dry. P1 found creating *"really accessible. I didn't need to go to the lab and then paint if I had any ideas come up. The paintings [also] dry pretty slowly, so I can make adjustments when it's still a little bit wet, or I can add layers once dry. That's more convenient to do"*. One of our participants used the opportunity to try out a family hobby 3D printer, and was able to go through many failed prints within a shorter period of time. They reflected on how if this was done within a lab environment the iterations would have been much more spread out due to having to work within lab hours. Overall being at home gave them more flexibility when crafting – as they could work when they liked.

6.3 Tensions Between Custom and Shared Infrastructures

Focusing on craft enabled individuals to personalize and customize their work, and due to the different form factors that this took (varying from painting, textiles, and candles), as well as different interactions, participants chose different hardware to best support their project. The benefit of this approach to custom infrastructures is that their hardware best supports their individual project. The trade-off is that working on unique hardware makes peer-to-peer learning more difficult.

6.3.1 Different local availability for specific physical components. Depending on our participants locations they had very different access to components. Some components are only available within specific countries, or have wait times that are impractical. As a result, our participants often had to rely on local availability of components. *"I remember that some stuff was harder to get because it didn't ship to [country], or had like a really long shipping time"* (P5). Specialty items, such as thermochromic pigments, where not available on all continents. As P2 summarizes: *"There weren't any in my home country. And so I had to search for ones that were in other countries, and apparently they were sold out in Europe, and the ones that were there were like super expensive, and then the other option was that I was like looking for thermochromic pigments across North America"*. P2 ended up relying on friends traveling back from North America to get the materials they needed. In contrast, certain materials were easier to acquire and less dependent on the country participants were residing in: *"The easiest materials were the resistors and the LEDs and the jumpers. They were quite common and I could find them"* (P2).

6.3.2 Lack of access to lab equipment for making and troubleshooting. Our participants had different access to supplies, as well as custom components that they ordered based on their crafted project. For example, some individuals decided to 'hack' commercial components, such as diffusers, resulting in troubleshooting issues that only they could address. P1: *"I couldn't really figure out how to override the code to make the diffuser work as I wanted to, and that's why the entire program [took more time]"*. Industrial equipment for troubleshooting, that individuals would have normally had access to in lab environments, was impractical or overly expensive to purchase. To support this experimentation, participants often purchased excess electronics for experimentation, but there is a gap in easy-to-access troubleshooting tools.

6.3.3 More shared infrastructures for peer-to-peer learning. Our participants discussed the benefits and limitations of using hardware that best suited their individual projects. By using specific hardware (varying from Arduino Uno, Bare Conductive Board, Adafruit Gemma, and Raspberry Pis) our participants had a more usable experience, in that the board was targeted for the specific materials or interactions they wanted to address, and in doing so supported their crafted interactions. As P5 summarizes: *"I was using one that was best suited for mine"*. The limitation of this from a usability perspective is that there was less peer-to-peer support possible. For example, the two individuals who used Arduino UNOs were able to help each other out virtually with tips and recommendations, whereas the others using different hardware found that more difficult. For example P3 hypothesized that similar hardware would shorten troubleshooting times: *"if someone had a problem, you would be using the same exact model as everyone else, and [be] there to debug"*. Depending on the context of 'Making from Home' research, researchers might choose to provide a more custom approach to support individual projects, or use similar infrastructures to support peer-to-peer learning, i.e. using the *"same materials to make different things"* (P5).

6.3.4 Ensuring designing participants can 'level up'. One of the limitations of using custom hardware for each, is that though a board might support an individual's specific project, certain boards support further 'leveling up' while others do not. For example, there is more infrastructure built around the Arduino UNO for adding Wi-Fi connections, or similar add-ons, whereas other boards such as the Bare Conductive and Gemma are made specifically for crafting, and adding on more functionality later as projects are iterated on can be more difficult. Depending on the length of the project and amount of iteration time, researchers will need to consider the trade-offs between boards meant for specific applications, and the ability to add more functionality on later.

6.4 Talking About Tangibles Virtually

6.4.1 Harder to explain tangible issues. Overall our participants said it was harder to explain tangible issues virtually and had difficulty explaining their circuits to others, as well as understanding recommendations they received on how to correct them. As P5 summarized: *"Sometimes it can be really hard to explain yourself or like a problem you're having in words. [You are] physically kind of like holding it up to the camera. It's not working, and it's kind of hard to explain because you can't see it".* Due to the difficulties of sharing and visualizing problems, issues needed a lot more back-and-forth clarification, as summarized by P3: *" we'd have to ask 'Oh, did you mean this?' And then after it's like, you know, a day later, maybe they see the message would be like, 'Oh, yeah, I didn't mean this.' But then I think that amount of time would have been wasted in terms of like getting valuable feedback.*" At the same time, having to externalize their process led to certain benefits. Here we discuss the benefits and trade-offs of communicating virtually on tangible projects for physical computing.

6.4.2 Having to document, and externalize the process is useful later. Our participants reported that communication for tangible projects required more work than communicating in person: for example, *"emailing with attachments, or like pictures of how the things look, or like videos of maybe how the Arduino's working, or if the sensor is working or not*" (P2). Our participants spent more time sketching out their circuits and diagramming their process in order to communicate their issues and steps with the team. Though this is more work up-front, it also encouraged our participants to document their work, something that is often difficult to get participants in the habit of doing. One limitation is that home environments are not always conducive to documentation, such as having an ideal lighting setup for clearly showing one's work. As a result, one of the participants highlighted that a kit for documentation was especially important, such as including a small portable lighting kit, or including mirror webcam attachments so that they can more easily share their process with others. *"I remember [it was] particularly difficult to take photos and process photos [in my home]. I took my desk lamp and tried to make it without those shadows, and then found a white table. It was quite the process to get like a proper white background and proper lighting. Maybe invest in like a good camera set up that like shows your hands when you're making something, because I feel like talking about things you're making isn't ideal*" (P5).

6.4.3 Tensions between synchronous and asynchronous communication. Our participants were living in different cities throughout this project, and some within different countries and time zones. This resulted in a mix of synchronous and asynchronous communication on these projects. Participants that were able to meet synchronously found that it helped with accountability, returning to the project, and preparing for the virtual meetings. They also reported more feelings of support, being able to have free-flowing conversations about their projects and not feeling alone in their work. Individuals living in different time zones often relied on asynchronous communication. Depending on the location they were in, there were also compounding issues such as internet connectivity, as P2 summarized: *"my internet connection in my home country isn't very stable, and so like having the zoom call is definitely gonna take lots of 'Can you repeat that?' and things like that. It's very glitchy. And so definitely emails are much faster*". The benefits of asynchronous communication is that it gave individuals time to think and reflect upon discussion topics. *"It's helpful because you get some time to think on a part - like a problem that someone posted"* (P3).

6.5 Testing Devices In-Situ

6.5.1 Making devices personally meaningful. Making their devices from home with a focus on craft enabled our participants to make devices that were personally meaningful. They interviewed their friends, family members, and roommates to better understand what they were craving or missing during this time of stay-at-home living. As a result, most of their projects aim to bring the outside (nature and social interaction) inside, to support their loved ones through this time. They used creative activities to plan out their design such as sketching and painting which gave them further feelings of ownership over their designs.

6.5.2 Crafted devices were designed for home. Their crafted devices were designed for the home sphere and to fit within their living spaces. For example, in the follow-up study, our designing participants who worked on textile crafts still had their items featured in their present-day interior design. For example, the Punch-Concert was in the background, hung on the wall, during the Zoom follow-up interview. Our participants spent time designing their devices for home, using the craft to disguise the technology and blend it into their living spaces.

6.5.3 Making and testing devices in context. By deploying the devices at home and testing it with friends, loved-ones, and roommates, they were able to better understand the impact of having these devices within that space. In contrast, the insights they received would have been harder to evaluate in a lab setting without that continued use. Participants highlighted that some home spaces might not be suitable for making. For example, P1 felt they had a *"really good housemate at that time. They didn't really mind that I used the public space. So I just built some paintings in our living room because my room didn't have an open window. I can't really do oil paint [without a window due to fumes] so I had to do it in the living room*". Depending on the materials they are crafting with, home spaces might be conducive or limit what types of crafts are possible.

6.5.4 Limitation of home sphere for running studies. The limitation of running studies in a home sphere is that devices at times had to be 'tuned' to each unique living space. For example Liya was created in a smaller space where the scent could more easily diffuse, but when moved to another, larger, room became less effective. Similarly, the Connectivity-Candle responded to movement near by, but depending on the structure of the room, or table it was on, would pick up different noises and was more sensitive within certain homes. 'Tuning' required more effort on the part of our participants, whereas in a lab setting they would only need to tune the item once.

At the same time, this process gave them a more realistic impression of how the devices would function "in-the-wild".

7 DISCUSSION

Here we discuss the benefits and trade-offs of 'Making from Home', how users were empowered by the process, and harnessing the power of craft.

7.1 Benefits and Trade-Offs When 'Making from Home'

7.1.1 Tensions between diverse craft mediums and peer-to-peer learning. Supporting participants to choose the medium of their craft enabled them to make more personally meaningful projects that they still had even a year after the initial study. In this way, using crafting as a way into physical computing was beneficial, enabling them to utilize materials within their own space and leverage their hobbies. The result of the diverse crafts also resulted in individuals leveraging the diverse microcontrollers that would best suit their projects - such as Bare Conductive Board for touch capacitive textiles, or a Gemma for light-emitting textiles. The reality is that individuals living in different countries will likely have to purchase hardware based on what is available locally, so having flexibility for different components is important [36]. The potential limitation of this is that there was less peer-to-peer learning. To support more peer-to-peer learning, researchers could decide to use the same infrastructure for all participants, but this might limit the craft mediums possible for making, and create issues for participants who live in locations that don't have access to specific electronic hardware stores or brands.

7.1.2 Mailing kits versus utilizing local materials. In previous work on supporting physical computing from home, researchers have predominantly used mailed-out kits, where all participants started off with the same base materials [3, 77]. The limitation of this, especially when participants are distributed in different countries, is that participants might not receive materials within the project timeframe [77]. Kits might be more useful for studies where individuals all live within the same city or country, and where it might be feasible to deliver items within a timely manner [3]. Our participants also brought up the importance of having documentation equipment, and researchers might consider instead of sending material kits, to send small portable lighting kits, webcam mirrors for seeing what individuals are doing with their hands, or overhead cameras. Using overhead cameras and creating a "studio" set up was an important finding from previous work on individuals teaching crafting tutorials during the pandemic [35].

7.1.3 More work in externalizing tangible processes, but this also helps build documentation. Though our participants found that virtual communication for tangible prototyping required more effort, with more sketching and diagramming required, as design researchers this friction might be useful as it forces participants to externalize and document their process throughout. Researchers wanting to encourage participants to document their processes might actively decide to choose virtual methods for this purpose. Similarly, research teams could actively choose Zoom versus in-person workshop sessions purposefully so transcription documentation can be captured and there can be traces of the iteration process. Increasingly researchers exploring how we can more easily create this type of documentation process throughout the making cycle, for example using think-aloud processes to create tutorials [40].

7.1.4 Supporting hybrid crafts without lab equipment. Many of our participants purchased excess materials due to a lack of access to industrial troubleshooting equipment that is often available in lab settings. Increasingly, HCI researchers are developing hybrid craft tools to better support DIY-at-home practices such as the Threadboard [31], and e-textile testing tools [71, 72]. The gaps our participants found in their troubleshooting process further support these efforts to provide more accessible troubleshooting equipment for physical computing. At the same time, we want to make sure that they can then 'level up' to commonly used tools, a good example being the 'Needlework probes' that can be used with lab multimeters [70].

7.2 How Were Users Empowered?

Unlike previous work that included sophisticated fabrication methods [24] or techniques relying on expertise [64] to create custom sensing and actuation capabilities in aesthetic designs, our design research aimed to empower users. We explored how DIY methods of making support users who are novice to interaction design and empower them through simple means of lowering barriers to entry. The use of low-cost materials and tools supported crafting and accessibility [37] and engagement of underrepresented groups who are often marginalized from mainstream tech design.

7.2.1 DIY Making. We encouraged participants to utilize low-cost DIY making methods with off-the-shelf materials and iterative methods that can help embed interaction in real-world objects. P1 used the laser cutter in a local MakerSpace to make her Liya frame and P3 used a domestic 3D-printing machine in her basement to design the Connectivity Candle. Similarly, the rest of participants were encouraged to utilize any creative skills they may have —or want to learn— as a means of creating what represents them.

DIY making supported culture-based design which is evident by certain aspects of the prototypes, from design concepts (aiming to ease cross-cultural tension (Liya) and aspire for global harmony (Monaxiá) to naming inspired from Chinese (Liya) and Greek (Monaxiá) terminology. Furthermore, DIY making and accessible prototyping helped us employ inclusion in our participants (with gender balance) and designers (where each is from a different cultural background) and empowered an all-female design team to extend their knowledge and practice into the area of physical prototyping.

7.2.2 Craftsmanship. The data collected from participants in these three studies goes beyond their anecdotal reflection and created prototypes. The data generated extends across the aesthetic layers of their creativity and thought processes. This layering of found data includes sponging paint on top of 3D prints (Connectivity Candle), adding invisible layers of art elements that only reveal conditionally (Liya, Monaxiá), crocheting and punching yarns with conductive threads (Punch Concert, Party Placemat), and thorough experimentation of mixing a matrix of essential oils to create unique expressive interactive scents (Liya). Crafting the prototypes in this way made them more personal than sleek interfaces made from cold materials (such as metal, acrylic, and glass) increasing appreciation and product attachment [62]. This connects to the two other intertwined strands of *Materiality* and *Connection with others* who would feel the personal touch of their loved one (i.e. the maker). We are not suggesting an agenda to start designing only hand-crafted prototypes. Instead, this finding highlights the potential of craft in supporting (*remote*) interaction between people in a personal (and *tangible*) way.

7.2.3 Lived Experience. The situated deployment of the prototypes in 7 different households showed how these prototypes were considered "*conversation pieces*". They provoked discussion, provided another avenue for users within a relationship to connect, and encouraged users to reflect upon their interactive experience. The pieces themselves provided company and "*filled the space*" by appealing to the senses through colour-change, sound, and touch. Users went through the stages of curiosity, exploration, and familiarity while interacting with the prototypes. Overall, the prototypes had an emotional impact on users, and rather than being a mere addition to the space decor, encouraged a more mindful experience.

7.3 Harnessing the Power of Craft

This project unwrapped the use of craft materials and practices to create an interface departing from screen-based communication to physical and tactile connection. Our studies empowered people to 'craft their identities' [18, 58, 73] in non-focus demanding ways [28, 55]. This allowed shifting from domestic devices [10, 28, 29, 80] to home things [52, 63, 84] that have significant impact on users' lived experiences. Recent research trends confirm the different design qualities between a 'device' and a 'thing' designed for the same purpose in a domestic setting [34]. Our research also aligns with previous work that shows how textile-based interaction [6, 52, 53] and crafted artwork [58, 63] (as opposed to sleek boxed [39] or cylindrical [14, 88, 89] devices) are more fitted into the nature of domestic environments and more adoptable in daily use (e.g., in wearables [18] and furniture [6]).

Crafting interactive homeware should make users think, wonder and reflect beyond a single instance of a prototype encounter. Such digital artefacts may not (and should not) be as addictive and demanding as today's industry-driven digital devices, but can be more fulfilling, promoting self-care, and supporting deeper values. When people design technology for themselves or their loved ones, they don't necessarily design tools to solve problems, but often create what expresses their feelings [78], reflects their identity [58], secures their fears [9], preserves their memories [24, 63, 84], gives meanings to things [50], connects to the world [57], and connects them to others [52].

8 CONCLUSION

This paper addresses the methods of empowering users to create their own tangible interfaces, while 'making from home' with a focus on craft. We explore their experience of making using a design brief around stay-at-home use. We present the results of the directed study with five studies with 17 participants who ideated a set of tangible homeware and reflected on their making and living with the prototypes. Through research-through-design and autoethnography, we engaged with participants throughout the process of designing, building and deploying their fully functioning prototypes in their households. We then did a set of follow-up interviews with the five designing participants to better understand the benefits and limitations of making-from-home using a craft approach. In this paper, we thoroughly discuss the design, crafting process, and reflections of long-term use of each prototype.

We found that making from home encouraged participants to recognize subtleties in the interactions and materials over prolonged use, how crafting and their crafted prototypes encouraged remembrance, the importance of tactility, the use of imperfection and metaphor in home goods, and how unspoken communication can provide support (RQ1). In our follow-up interviews, we found how participants dealt with ordering their own materials, how participants focused on crafting before computing, tensions between custom and shared infrastructures, and the benefits and limitations of virtual communication for physical computing (RQ2). Our results show that when people design technology for themselves or their loved ones, they don't necessarily aim to solve problems, but may often design for self-expression, self-reflection, remembrance, or social engagement. In this work, we discussed the benefits and trade-offs of 'making from home' such as: (1) diversity of mediums versus peer-to-peer support, (2) mailing kits versus using local materials, (3) the extra work that virtual methods require for tangible prototyping, but also the potential benefit of encouraging documentation throughout, and (4) difficulties troubleshooting without lab equipment. Through our critical reflective reporting of our designer-user approach, we aim to further support distant design research (where researchers and participants are not co-located in the same space) in the HCI community.

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