

# COVIDware: Designing Interactive Everyday Things as Tangible Homeware for Social Isolation.

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**Abstract.** This paper describes our collaborative journey of creating everyday interactive artefacts to help us think, reflect, and live through self-isolation. Through a co-design approach, we designed interactive homeware objects (that we collectively refer to as 'COVIDware') to address the challenges of isolation during the pandemic. Five artefacts were developed by self-isolated designers as interactive art installations. We discuss how each creator reflected on her design concept, process, and encounter through concepts of critical making, speculation, and engagement via in-the-isolated-wild deployments. By empowering early researchers/enthusiasts to design 'with' smart-materials, and off-the-shelf items, we reflect on how these homey interfaces can enhance people's wellbeing beyond screen-based interactions. Despite not collaborating in the making process, our findings from the designer's making process show how all the designed artefacts shared attributes of biophilic design, imperfection, and unconventional interactions with the overarching goal of promoting wellbeing, and meaningful connection with nature, self, and others.

**Keywords:** Colour-change, Olfactory, Home, Domestic, DIY Making, Prototyping, Interactive Spaces, COVID-19, Craft, Tangible User Interface.

## 1 Introduction

Strict social distancing guidelines during the COVID-19 pandemic have affected individuals and communities around the world. Feelings of loneliness and isolation struck despite the technological advancements that allow for multi-modal communication channels. With stay-at-home orders, the lack of in-person social communication with friends and family became more prominent. The 'new-normal' of physically-distanced interaction (due to immune or health reasons, quarantine, new variant regulations, and senior living, among others) warrants new ways of mitigating the loss of physical interaction.

As the prolonged circumstances of the pandemic persist, we need to learn to live increasingly *indoors* and *online*. To address these growing issues, research into visual, audible, tactile, and olfactory interaction can help with easing the entailed challenges [19,31] and improve mental wellbeing [56, 63]. Recent studies show that our reduced exposure to nature, interaction with others, and loss of indicators of time may adversely affect our health [4]. Being able to engage with others through tangible things [37, 47, 64], reflect with self [29], and being close to nature has a positive impact on individuals with depression [2]. Through tangible interaction, we can recreate the experience of communicating with people and nature and embed elements of this at home. Studies have shown how multisensory interaction (including smell-changing) can change human behaviour [23, 33], have anti-depressive effects [63], and enhance their overall wellbeing [32]. Our motivation also stems from the call of researchers and practitioners in the HCI and interaction design community (shared by Dalsgaard [8]) indicating that developing new forms of remote social communication is one of the ways to address “How can we contribute to shaping the new normal?”

Prior research in the HCI community shows how interactive technology offers great potential to support better and richer user experience. We draw inspiration from previous work around tangible everyday things [29], from early ambient interfaces to interactive furniture [14] and calm appearance-changing artwork [62] that explores people’s living practices around everyday objects. Following a research-through-design [70] process, we explored the design of interactive artefacts that build on concepts of ubiquity [66], calmness [67], slowness [17], meaningfulness [17], and ambiguity [13] as design values. Although there is some recent work that introduced novel gadgets to domestic environments, there is a lack of research that has focused on embedding interactivity seamlessly within existing everyday homeware and reflecting on how novice designers approach design briefs and reflect on them. In this paper, we share three key contributions:

- **Exploring screenless connection** with the outside world using interactive homeware (i.e. COVIDware) that could potentially be part of our new normal (i.e. need for home isolation) supporting our engagement and connection with ourselves, others, and nature.
- **Designing five artefacts** as design tools for understanding COVIDware that: 1) expresses visuolfactory outdoor experience and reflect cross-cultural unity; 2) physicalize tensions of disconnectedness and self-isolation through metaphors of slow, calm, and ambiguous art; and 3) augment isolated dining spaces to promote screenless connectivity between separated loved ones in tangible meaningful ways.
- **Articulating the impact** of COVIDware on living through COVID and with the artefacts by methods of co-designing with 5 designers, and self-reflection on the designed artefacts during a stay-home lockdown.

## 2 Related Work

Our work is based on literature from four main areas: ambient interaction, interactive things in the home, interfaces for distant or isolated users, and design processes during COVID-19 through the lens of DIY and maker-culture.

### 2.1 Ambient Interaction

Studies have found that incorporating technology into everyday decorative objects in the home encourages meaningful interaction with objects that individuals might not notice otherwise [37]. These objects can also help reduce display blindness [22], increase empathy with a remote event [55], or even connect individuals with deceased family members [63]. Research has highlighted the importance of reducing focus-demanding technologies [17, 40], infusing personality into decor and matching the materials to the messaging [42, 50]. We have seen tremendous strides in function, and it is important that we promote the same inquiry and innovation into form. It is crucial that the decor plays a supporting role in a greater purpose and is not distributive or isolating [16].

### 2.2 Interactive Homeware

Interactive furniture helps to enrich an environment and emphasizes symbiosis between the user and the artefact [22]. Examples of interactive furniture include the classic History Table-cloth [14] that changes illuminating patterns on a kitchen tabletop using pressure sensors to reflect the history of use over time; while the matching Peace painting and table [42] change colour gradually with proximity 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 Western design practices. On the other hand, examples of decorative elements around the home such as the situated studies of the Photobox [47], Fenestra photo frame [64], ActuEater [37], and transTexture [68]. Such situated studies of interactive homeware aimed to engage with the present, past, tangible interactivity, and materiality respectively.

Limited research explored new ways of creating dynamic, interactive, interior spaces to enhance people's experiences. Interactivity embedded within everyday things around us can be a source of social engagement [37], a source of decorative and aesthetically pleasing design [34,39], or a source of connectedness to oneself [42]. For instance, the Textile Mirror [9] explored the possibility of creating affective artefacts using smart materials that reflect users' feelings but was not studied in-the-wild. Other in-situ studies ---beyond the home--- focused on self-reflection including DayClo [29] which targeted the contemplation of one's scheduling practices through an interactive analog clock.

### 2.3 Social Isolation

Researchers have explored connecting distant families [12] or mediating intimate relationships [18] through technology, but most used screen-based interactions. Given the great potential of tangible interfaces and embedding multisensory interactions in everyday things, the absence of such interventions in the context of a global crisis is a major current gap and a missed opportunity. Limited research during the lockdown restrictions (and largely because of the restrictions) looked at supporting people working from home [52], studying at home [1], prototyping tangible interfaces at home [7], or connecting with distant loved ones [20, 57], but all using screen-based technology. ‘Making’ during the pandemic focused on the design and rapid fabrication of face-masks [5, 15]. Design fiction has proved to encourage people to communicate sensitive topics, such as reimagining how interpersonal relationships will look like post-COVID [58]. Moreover, Speculative design was used to explore post-COVID gamification scenarios [61] using design fiction. In our paper, we explore how the impact of COVID can shape the future of connection between individuals through design fiction and speculative design.

### 2.4 Maker-culture During COVID

In the work of Crisis Couture [5], researchers explored how makers wanted their designs to be "a statement of empowerment", and how designers support people in ways they individually feel and choose to be protected while wearing a mask. Lee et al. [30] devised a design process in the form of turn-based collaborative games for embroidery crafters to enable ‘play-by-mail’ alongside in-person players. Still, no other work has been done that explores design processes during lockdowns or how people can be empowered to create interfaces themselves that meet their own needs and preferences.

A few publications during the lockdowns of 2020 and 2021 unwrapped some DIY methods and low-cost accessible materials for prototyping [7, 25, 38] but relied solely on the autoethnography of the lead author carrying out most of the design process. Limited work developed new methods for DIY physical prototyping to empower novice users in the HCI community interested in DIY making to build affordable and easily deployable circuits, whether using e-textiles to build their own circuits in the future [21, 27] or microcontrollers for their research [53].

## 3 Exploring COVIDware

In this paper, we introduce the concept of ‘COVIDware’ to refer to tangible interfaces designed for applications related to supporting people living through pandemics, lockdowns, and self-isolation. Even post-pandemic, we believe this notion will continue to be needed, not only to reflect on one of the most life-changing circumstances which people have experienced, but also to advocate for designing through/for/with individuals and groups who will continue to choose to self-isolate. If

most of the population in developed countries is expecting to be back to somewhat-normal relatively soon, millions will remain underrepresented and systematically marginalized in future research including people who are immunocompromised, unvaccinated individuals, people with disabilities, those living in remote areas, and older populations. The concept of COVIDware opens a stream for ongoing research on isolated users and designing interactive physical artefacts that help people connect with the world but also blend in their environment as typical everyday homeware or officeware. Herein, we reflect on some examples of designing and living with COVIDware along with some remote design research methods, practices, and challenges.

## **4 Method**

To unpack the concept of COVIDware, we ran interviews with 5 designers generating 7 artefacts (2 of which are pairs) that were deployed. Herein, we discuss our methodology for this study using a Research through Design approach (RtD) and present the methodological approach, participant recruitment, and data analysis, before we highlight the key learnings from the perspective of critical making, critical speculation, and critical engagement.

### **4.1 Methodological Approach**

For opening up this new design space and exploration through making, we adopted the Research-through Design (RtD) [70] approach and Critical Making [24] methods. We also utilize methods of Critical Speculation [11, 58, 65] and encouraged designers to think outside the box of existing technology through design fiction [3] to further allow for the articulation of the metaphors used throughout their designs. In addition to textual accounts, we relied heavily on the visual and pictorial data collected from the design process and the brainstorming session (Miro Board) as viable forms of research, not just for documentary but as indispensable [60] to user-centered design.

Research-through Design methodology has been widely used in the past decade [70]. It involves the design of artefacts to answer research questions or to develop new theories and paradigms for designers. RtD has been critiqued for often being used out of familiarity [71]. However, to answer our research inquiry on how to connect people during social isolation, RtD is a desirable approach as it would help us understand and articulate how everyday things can be utilized for users' wellbeing.

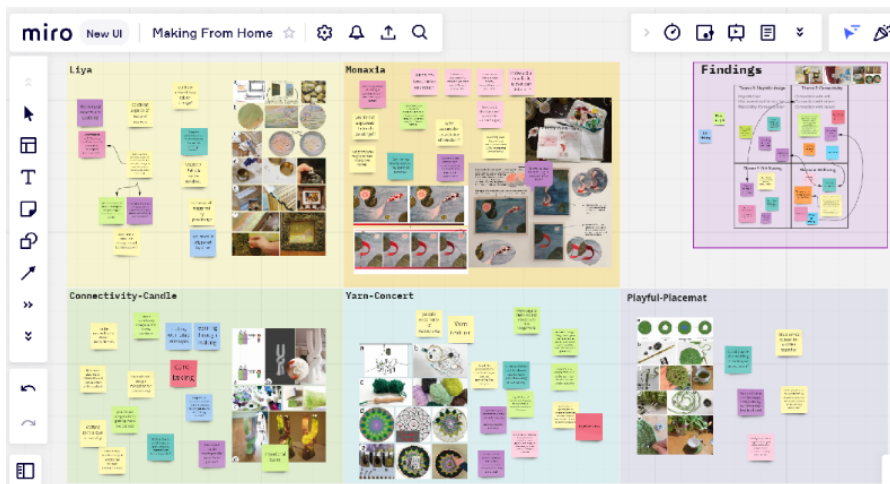
Critical Making [24] involves the articulation of the material production of physical artefacts. Since we would be designing for everyday things at home, exploration of materials for the design of these artefacts is necessary. Furthermore, Critical Speculation [11, 58, 65] involves fictional approaches [3] to designing, where we expand our horizons from what is already there, to what could be, which can be done through fictional scenarios, or novel interactions. Our work involves novel interactions that have not been deployed before for connection and thus requires critical speculation of how they could be designed.

Data collection included quotes from interviews, visual content of images and videos that designers captured, and their reflections where they draw on their design process and own reflection of their created artefacts [44]. These methodologies are all woven together in their requirement for novelty, critical thinking, and understanding of why and how different materials, artefacts and interactions can be used with users.

## 4.2 Participant Recruitment

During the COVID pandemic and lockdowns enforced by local authorities, 3 designers were recruited by email then 2 more were recruited by snowballing. Our criteria for designer recruitment were: 1) People who have an artistic background, and/or are passionate about design, making, or crafting; and 2) Interested in applying innovative technology in creative ways. Experience in electronics was not necessary but valued. Each designer was working alone from their residence during a stay-home order lockdown without ever meeting any of the others in-person. Our study involved five designers (female; age range: 20-30) who were university students studying computer science.

For our team's reflective brainstorming session after the study, we invited the designers to a Zoom discussion to utilize its break-out rooms feature where each room/sub-group discussed certain aspects and then shared back to allow different threads of ideas. We also used the online Miro collaboration platform (see **Fig. 1**) both synchronously (during our brainstorming session) and asynchronously to add, group, and link any after-thoughts or reflections. Unlike most shared documents, this method allowed real-time visual collaboration on a pictorial-fluid whiteboard supporting our design research nature.



**Fig. 1.** A screenshot during the online analysis of the studies using the Miro whiteboard ([www//miro.com/](http://www//miro.com/))

### 4.3 Analysis

The artefacts that we wanted to create as COVIDware needed to have a durable relationship between people and things in terms of what they do, what they mean, and what they are made of in the broader sensual appeal. Odom's Theoretical Framework [46] discusses the factors that affect the user's attachment towards the artefacts which we use in our analysis. Namely, we shed light on the functionality of the artefact, what it means to its user, and what are the physical qualities that make up this artefact. These factors are necessary to evaluate how the materials of the objects engage and augment the user's daily life. Since this framework was developed to address the attachment and sustainability of personal (interactive) artefacts within everyday environments, it powerfully allowed us to understand the diverse yet similar underlying function, symbolism, augmentation, and material and aesthetic qualities of the designs.

Our study produced five different artefacts, each built by one of the five designers. We divide these experiments into three case studies where: Study 1 with D1 as the designer yielded the first artefact Liya (A1); Study 2 with D2 as the designer yielded the second artefact Monaxiá (A2); and Study 3 with D3, D4, and D5 as a group of 3 designers (developing together an overarching theme for their work) yielded three more artefacts (A3, A4, and A5).

**Liya.** This is a framed painting with biophilic qualities that changes its hue and interactive capabilities. We utilized critical making to choose the type of paint to reflect how impressionist artists painted, realizing that oil paint with thermochromic pigment would result in the desired look and feel of connecting to nature through impressionism.

**Monaxiá.** We utilized critical speculation and design fiction to explore how we can metaphorically articulate ideas of isolation and the need for connection. Through Research-through Design methodology, we experimented with different displays, colors, and characters that would convey such meanings.

**Together Apart.** Three case studies were developed from Together Apart, utilizing critical making and speculation and Research through Design. The three case studies articulated different materials, different forms, and different interactions. Connectivity Candle explored how it can convey feelings of connectedness between individuals through organic and biophilic design.

Finally, to help gain a deeper understanding of COVIDware and help generate design opportunities and implications based on our study, we ran a 90-minutes brainstorming session among the research team. During this activity we analyzed all the artefacts again from experiential and design perspectives asking ourselves "What did we learn from this project?" and "how can the research community build on this work?". This reflective data analysis enables us to review and synthesize examples of COVIDware created in this project through a number of intertwined strands that form the key learnings of our contribution.

We documented the design process, the design iterations, and the results from the brainstorming session. In the following section, we elaborate on their design process and materials explored during the making of the artefacts.

## 5 Studies

Herein, we present our COVIDware artefacts, their concepts, design, implementation, interactivity, and reflection.

### 5.1 Study 1: Liya (A1)

Liya, which is a Mandarin term (li-ya 离压) that refers to being ‘out of stress’, was an art installation created by D1. The artefact she designed was meant to simulate the sensory experiences felt when experiencing nature outdoors, ranging from an olfactory experience to a visual one. The installation created was a painting on canvas with a moss-filled wooden frame (see **Fig. 2**). Besides being a simulator of nature, it combines different cultural painting methodologies which makes it unique in, not only function, but also form. By adding different smart materials and electronics to evoke these sensory experiences, D1 describes her artefact Liya as one that “*provides a multi-sensory experience and aids in creating and recalling memories*”.

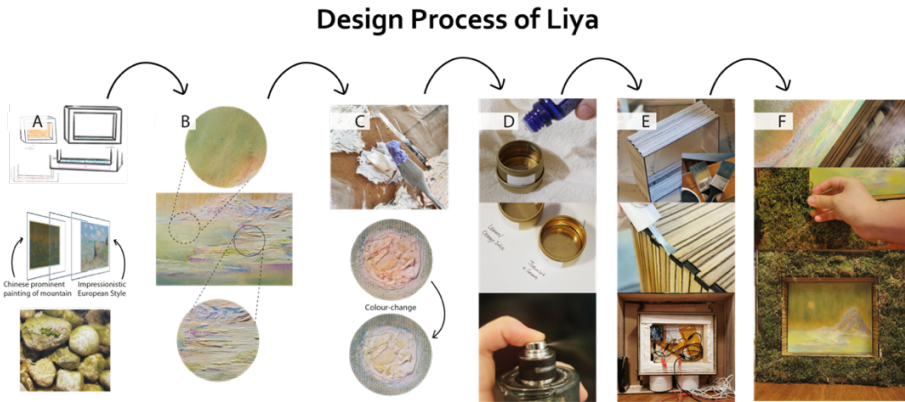
**Design and Implementation.** D1 explains her artwork as inspired from both Ximeng Wang’s Chinese traditional painting “A Thousand Li of Rivers and Mountains”, and the work by French Impressionist Claude Monet “The Cliff Walk at Pourville”.

D1 intentionally also incorporated inclusion into the painting techniques themselves by combining both the Chinese brushing technique and the European impasto knife technique of hand-painting. D1 experimented with colour-changing powder pigments that, when exposed to heat, change their hue. The main colour transitions were black, red, yellow, and blue to transparent. She utilized this functionality for a sensual output that allows the painting to darken or light up depending on the time of the day, thus simulating how days progress slowly in nature. She relied heavily on not only the given colours but also on mixing them to paint with hues that have positive effects on one’s welfare as suggested by previous research [6,45].

The physical artefact’s interactivity relied on 1) colour-change and 2) olfactory change. The colour-changing element required the input of heat, which was met by adding heating pads behind the painting and triggering the heating pads to heat up when the time of the day changed. As for the olfactory change, D1 used DIY scent diffusers with different essential oils that would get triggered to diffuse scent depending on the time of the day. Both interactivities were controlled by a microcontroller (Arduino Uno). The Arduino UNO controls when to trigger the oil diffuser and the heating pad to turn on. D1 wanted to control them depending on the time of the day. That way, the painting’s colours would shift to cooler hues (Blues) during the night and warmer hues (Reds) during the day. As for the frame, D1 laser-cut a frame out of a zebrawood as it



has an “*organic pattern that resonates with the project theme: bringing individuals the feeling of nature indoors*”. The frame was wide and deep; the former to enclose the diffusers and the latter to embed moss and enhance the overall experience of the installation, making it further tied to nature.



**Fig. 2.** The design process of Liya: a) Sketching and inspiration; b) Experimenting with different art techniques from Chinese and European cultures, incorporating brushing and knifing techniques; c) Exploring the effect of adding thermochromic pigments with oil paints; d) Combining essential oils (12 different oil scents) to simulate daytime and nighttime in nature; e) Embedding the circuit that controls the colour-changing and olfactory elements of the installation in a laser-cut frame; f) Polishing the frame by adding moss and testing the deployed circuit.

**Novel Interactivities.** D1 demonstrated novelty that extends the traditional visual experience of an interactive design to incorporate an olfactory experience. Through experimentation to test the different mixtures of essential oils, D1 was able to simulate the daytime and nighttime experiences. Since daytime is related to a sunny and energetic aura, D1 blended oils with scents of citrus, wood, and flowers. Behind these attributes, D1 hoped that “*while keeping one’s mind relaxed, the viewer can also have an awareness of time to maintain the connection to the outdoor environment and ease the tension caused by staying indoors for a long time*”.

D1 stated that Monet inspired her use of thermochromic pigments which change colours as temperature differs to change the impression of the painting from a view during the daytime warmer hue to a night-time cooler hue. Initial mixtures of mineral and thermochromic pigment resulted in a medium that would dry quickly but was slow to increase in temperature and change colour. Once heated, the media selected also failed to retain colour and heat to sustain a viewing experience longer than a few seconds.

Alternatively, D1 decided to try mixing oil paint and thermochromic pigments. Comparatively, D1 noted that: “*the thermochromic pigments and oil paint mixture conveys the message of the slowness of daylight changing more efficiently as it heated quickly and retained heat for a more extended period*”. Although previous work focused on mixing thermochromic pigments with acrylic mediums only, D1 found that

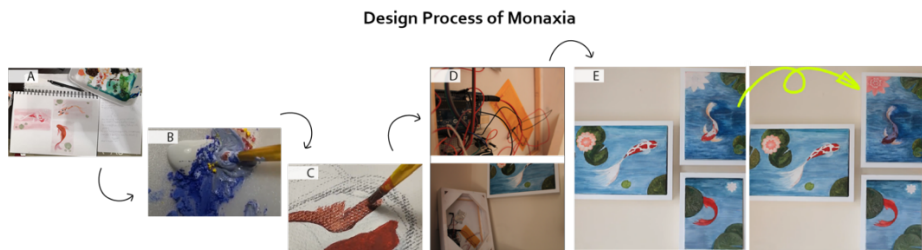
the nature of oil paints “*allowed for the build-up of layers and increased the richness of hue; it adds depth and expresses a sense of unrestrained spirit*”.

**Reflection.** In addition to all the insight gained from engaging with D1 in the design process, D1 reflected on her deployed artefact and understood different aspects of how can people interact with interactive COVIDware as Liya. D1 situated Liya in the living room “*where we [share] having dinner or watching movies*”. The designer also noted that Liya was unintrusive as it “*brings a little bit of colour to the living space*”. Liya supported the notion of connecting people who are isolated in their homes with nature’s scenery. In terms of design, D1 perceived Liya as a blend between the Asian and Impressionistic art styles as she understands the underlying design inspirations.

In terms of the concept of Liya, designers shared conversations during the brainstorming session about how they used to enjoy the outdoor pre-COVID but cannot anymore. D1 noted that her artefact can “*connect (me) with nature and kind of like the feeling of touching the nature a little bit*”. The added olfactory experience further enhanced D1’s feeling of connecting with nature as she elaborated on how: “*It lightens up my mood. The woody scents make me feel closer to nature, and it gives me a feeling that it’s pulling me away from my laptop. The more citrus and floral ones don’t give me this feeling*”.

## 5.2 Study 2: Monaxiá (A2)

Monaxiá, which is a Greek term that denotes the feeling of loneliness, was a COVIDware art-installation created by D2. She specifically chose this term as it represents the loneliness that one might feel during isolation. Instead of combining all interactivities in one painting, D2 expanded the interaction of her installation to be incorporated within three different artworks (see **Fig. 3**). Her main goal was to demonstrate the tension between longing for connection and being physically disconnected during isolation through the use of Koi fish as metaphors. D2 utilized slow, calm, and ambiguous designs to inform her design decisions in the making process.



**Fig. 3.** The design process of Monaxiá: a) Sketching the design concept using traditional paper and paint; b) Exploring the addition of different thermochromic pigments on acrylic paints; c) Transferring the sketched design concept on the canvases using acrylic paints mixed with different thermochromic pigments; d) Deploying the completed circuit on each of the canvases. Each canvas can trigger the activation of a heating pad in another canvas based on the input from a capacitive touch sensor; e) Testing the wall-art after displaying it with all circuitry concealed.

**Design and Implementation.** Nature's ponds and seas were a source of inspiration for D2. The water's ability to tune down all voices around us once we dip under water seemed to reflect the idea of disconnectedness well. D2 noted: *"All voices become muffled and indistinguishable, and our voices are no longer our way of communicating with each other."* D2 further articulated life under water by mentioning the Koi fish's prominent warm hues stating that: *"Koi fish is a known symbol for aspiration and advancement and is well known for its abundance. These are all attributes of modern communities striving to live together in harmony"*.

Monaxiá is an art installation made up of three canvases, each having different dimensions (sizes: 30×24 cm, 40×30 cm, and 45×30 cm). D2 utilized her passion for art to paint a shot from a pond, incorporating different elements that stretch along the three canvases. The scenery is of three Koi fish, each in a separate frame but facing each other, with floating leaves and flowers around them. While the whole painting was made using acrylic paint, thermochromic pigments were blended in the Koi fish and the flowers to alter their appearance upon interaction. The appearance of the fish would change from warm, bright hues to colder ones to further enrich the overall experience of interacting with the fish. D2 described the assortment of the three paintings as *"a shot of Koi fish interacting harmoniously with each other in their habitat, filled with leaves and flowers around them. The communication between different Koi fish is a reminder of the cultural diversity, inclusion, and globalization we live in"*. The flowers are used as a metaphor for blushing, an attribute associated with some forms of introversion.

Using three Arduino microcontrollers (2 Arduino UNOs and an Arduino Mega), each connected to an nRF24L01 wireless module, D2 established a bi-directional communication system between all three microcontrollers. To code the communication system, D2 used the nRF24 library which is available on GitHub. All Arduino microcontrollers were connected to capacitive sensors made of accessible DIY materials including Aluminum foil sheets.

The three wirelessly-connected circuits were powered with a 3.7V LiPo battery. For the colour-changing actuation, D2 used heating pads to heat the canvases. The thermochromic pigments were used in painting the interactive elements of the artefact (i.e. fish and flowers). Once a user interacts with any of the paintings by touching or standing in proximity to the painting, the capacitive sensor triggers a random signal to one of the other wireless modules. Upon the reception of a signal, the heating pad of that painting gets switched off, allowing the painting to cool down and change colour from brightly vibrant to faded or hiding away in the dark.

**Novel Interactivities.** Monaxiá is made up of three canvases that are placed as shown in **Fig. 3**. Wireless capabilities are embedded in each of them to enable communication between the paintings. When one of the canvases is touched, it sends a signal to one of the neighboring paintings, causing the Koi fish of that painting to change its appearance by triggering an embedded heating pad that would activate the thermochromic paint. The three canvases would send and receive signals between each other in response to user interaction. This varied interaction creates a level of ambiguity for the user as there is no direct mapping between their action (touching one canvas) and the response (another canvas changing colour). This sense of disconnectedness between one's input

on the canvas and the unrelated, unexpected output emphasizes the sense of confusion and incomprehension people might feel in virtual or masked social interactions.

The layout of Monaxiá's three frames was set so that all fish would be facing each other, each in a separate canvas with a different dimension. One might see it as spiraling inward, or "*coming together*". This form of a triangular setup creates momentum between three characteristics (described in the following subsection), represented by the three swaying fish making them seem connected as one, communicating in a seamless dialog, even though they are disconnected, each in its own world. The varied dimensions of the frames added further heterogeneity to the setup. The choice of the white frame was intended to be subtle to portray the connectedness in disconnection.

The first canvas, which is on the top right of Figure 3E, is a Koi fish that hides away from the observer by swimming deeper underwater, causing its vibrant colours to diminish and fade away. Some individuals shy away from social interactions by further isolating themselves in their own minds. Reaching out to them would need people to pass barriers built between them and the world around them. This form of blooming connection between one another is manifested in the form of a brightly coloured koi fish that avoids human contact by being out of reach deeper underwater. To achieve this effect, thermochromic blue was mixed with red acrylic for the red pattern, and with white acrylic for the white pattern. Once that layer dried, a layer of thermochromic blue and yellow diluted was added with water in ratios that would achieve the background water hue. In this layer, no acrylics were used as they would stain the whole painting with an undesired hue that does not vanish with heat (i.e., interaction). Furthermore, to enhance the paintings' dynamism and to communicate a sense of bashfulness, a white flower was added that turns pink when the fish hides underwater. D2 described this design decision as "*a metaphor for the human trait that indicates blushing*".

The second canvas, which is on the lower right of Figure 3E, shows a Koi fish that darkens their colour upon interaction. Its initial state is a bright red colour that symbolizes an energetic character that, when interacted with, turns darker as a way of hiding its identity from strangers. Some people might prefer to communicate their identities or socialize to only dearly close people but not to individuals who are not in their social and/or physical circle. To achieve this transition from red to black, D2 experimented with different thermochromic colours. Mixing thermochromic black with red acrylic did not give the desired effect as it left sandy gray stains with heat. However, mixing yellow and blue thermochromic with red acrylic in equal ratios gave the desired darkness of black with a tint of dark red that seemed to add depth to the fish's structure.

The third interactive painting represents individuals who are along the interaction spectrum but is not on either end. Even though the last painting has no total transition from one colour to another, it does, however, change its pattern i.e., changes its type to form another identity. Some people with dual identities (whether gender or cultural identities) may rarely expose their true identities to those around them, leaving an observer with a distorted or parallel image of their true selves.

**Reflection.** The installation, which is made up of 3 framed canvases, consisted of a shot of Koi fish that is initially brightly and vibrantly coloured in red and alters its appearance upon the user's touch. D2 reflected on her idea, stating that "*As many individuals have spent months in self-isolation, developed emotions of shyness and*

*isolation can be seen and felt in this artefact*". She aimed to create a thought-provoking artefact that, when contemplated, can articulate people's lack of communication during elongated periods of isolation.

The installation reflects a user's life in isolation. The artefacts long for connection the same way an isolated individual would, creating a connection with oneself when interacting with the artefact. This COVIDware wall-art depicts isolation and separation between individuals and their surrounding environment which is manifested in isolated Koi fish. Despite being separated, the Koi fish are all facing each other, yearning for a connection among themselves. The completed and deployed artefact with its colour transitions has enabled D2 to visualize and reflect on emotions of longing and connection through the artefact.

There was a total of three different fictitious characters represented as Koi fish in this study. Each of them emphasized a different user characteristic that isolated individuals might be experiencing. *Ambiguity* as a design concept was used to further engage the user with the artefact, anticipating how the interaction will affect the appearance of the painting. Furthermore, *slowness* was utilized to allow the user to observe how the painting transitions from one state to another, giving enough time for contemplation and reflection. D2 noted that interacting with the painting made her feel that she is part of this dynamic community of individuals longing for connection. Another intriguing concept was how the added randomness between interaction and response metaphorically emphasized the idea that people were reluctant to communicate directly in-person.

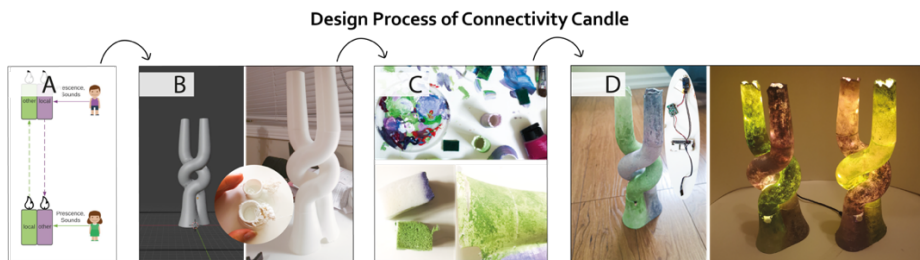
### **5.3 Study 3: Together Apart (A3, A4, A5)**

The third study involved three designers (D3, D4, and D5) and generated three pieces of COVIDware that were designed under one coherent theme. The three designers that took part in this study as a team developed the design concept of living 'together apart' due to the lockdown restrictions of the COVID-19 pandemic. The concept aimed to 1) promote screenless connectivity between separated loved ones, and 2) augment isolated domestic dining spaces.

The design team in this study designed and evaluated COVIDware that can help them connect while being physically in different homes during the lockdown. Designers brainstormed with others about what challenges they faced while being separated due to the stay-at-home order enforced where they lived. With the overwhelming feeling of "we're lonely" and the overarching theme of utilizing a "tactile experience" to "stay connected", the design concept revolved around the question of "how might we facilitate an asynchronous dining experience that helps us feel a bit together?". Designers developed their design concept on engaging people with screenless interaction through dining decorative things at home. This concept diminishes the unhealthy habits of the overuse of screen-based interactions while engaging different senses to connect with others in unconventional ways.

**Design and Implementation.** The team created a set of five artefacts that form a coherent theme and should function together in seamless interaction. D3 created a pair of the *Connectivity Candle*, D4 created a pair of the *Punch Concert*, and D5 created the *Party Placemat*. The design of each of these artefacts is detailed below:

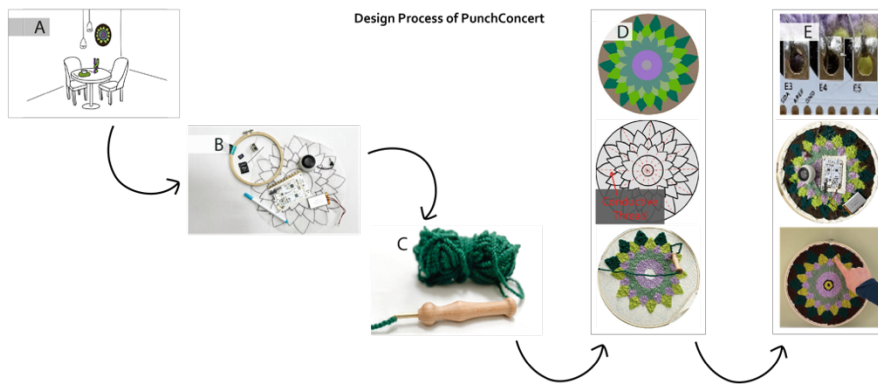
The Connectivity Candle (A3): D3 designed a pair of candles that can be wirelessly connected so that each can be placed on a dining table in a different household (enabling households to communicate through the candles). Every candle is in the form of two intertwining prongs, metaphorically representing the concepts of engaging in conversations and interactions between individuals during dining. D3 used a domestic 3D printer (CR-10) to explore the different structures that can be built for the candle. White PLA filament was used for printing since white can be easily colored. After experimenting with different 3D models using a 3D modeling tool, she printed the model in 3 parts (that were later glued together as shown in **Fig. 4**). This is due to logistical constraints including the size of the 3D printer and its error rate. To transition the candle from matte white to a nature-inspired look, D3 used acrylic paint and a sponging technique with earth-tones to paint the candles. Furthermore, D3 added texture to further emphasize the look and feel of a candle by burning the tips of the prongs, simulating the melting wax of real candles. D3 noted that the sponging technique was necessary for: *“creating natural analogues to moss. Humans generally prefer rich, textured haptic feedback rather than smooth surfaces”*. The Connectivity Candle was implemented using a Raspberry Pi Zero with LED string wire lights, LED current converters, a sound sensor, and an infrared sensor to detect proximity on the dining table.



**Fig. 4.** The design process of the Connectivity Candle: a) Illustrating the desired interactivity between the pair of candles; b) Building a 3D model of the candle and 3D printing it using white PLA, documenting unsuccessful attempts as part of the RtD approach; c) Experimenting with different sponges, brushes and melting of the candle to create the desired shape, form, and texture; d) Embedding the completed circuit with proximity and sound sensors inside the candle.

The Punch Concert (A4): **Fig. 5** shows the design process followed to create a punch-needle wall-art. Similar to the Connectivity Candle, the Punch Concert comes in pairs so that each can be placed on the dining table of two different households. The design concept of D4 was to create a floral pattern for a musical record with tactile sensing abilities. When a user interacts with a Punch Concert, the pair that comes with it gives audio feedback by playing a musical playlist. D4 experimented with potential

design patterns and musical playlists and, once completed, implemented the design on a 12-inch punch needling hoop. The design was sketched on a monk's cloth before punch-needling to facilitate tracing the design. D4 carefully considered her aesthetic choices when designing the artefact saying: *"I filled in the design using varying colours and thicknesses of wool, such as Bernat Soft Chunky Wool in dark brown, then sewn in conductive thread into the design and hot glued the ends to prevent fraying"*. She added further details and justifications to her design decisions with respect to the coherent theme as *"I used a floral pattern, greens, and earth-toned yarns to match D3's candle colours"*. The Punch Concert was implemented using a BareConductive TouchBoard together with conductive thread, a mini hamburger speaker and a 3.7V LiPo battery attached to the back of the piece using Velcro.

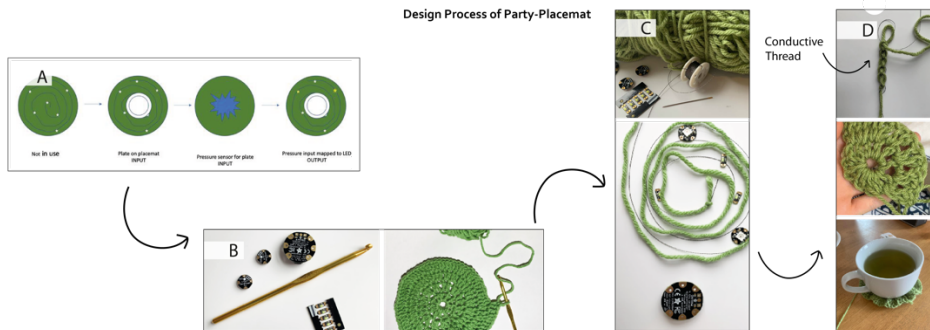


**Fig. 5.** The design process of the Punch Concert: a) Developing the design concept; b) Sketching a floral structure to be embroidered on a 12" embroidery hoop; c) Experimenting with different wool yarn colours and thicknesses to achieve the desired texture and nature-inspired tones; d) Design process; starting from sketching on a digital art tool (Adobe Illustrator), to parchment paper and finally punch-needling wool and conductive thread on Monk's cloth; and e) Embedding the complete circuit with audio output and touch capacitor behind the embroidery hoop.

The Party Placemat (A5): **Fig. 6** depicts the design process followed by D5 when creating her artefact. She designed an interactive placemat that responds to pressure by lighting up. Similar to A3 and A4, she designed a nature-inspired artefact which was evident in her choice of colours and the organically round form of the placemat. D5 wanted to follow the *"biophilic colour scheme"* of A3 and A4 and thus crocheted the placemat with an earthy-tone. Her exploration phase included unsuccessful attempts that caused her to skip stitches, or for the yarn to curl up. She used accessible Youtube tutorials to guide her to learn how to crochet a granny circle. For the final design, D5 used a 5mm crochet hook which allowed her to achieve the desired look but on a smaller scale. D5 wanted the artefact to have: *"a cozy home look"*. By learning through making, D5 tried *"figuring out the best way to incorporate conductive thread. At first, they were intertwined and crocheted together. Then, at the end, I sew the conductive thread into the complete crochet granny circle"*. The Party Placemat used the GEMMA v2 wearable microcontroller that is more suitable for textile-based interactive designs. The



design also included stainless-steel conductive thread for sensing and Flora RGB neopixels and white LED sequins for light.



**Fig. 6.** The design process of the Party-Placemat: a) Developing the design concept; b) Experimenting with different crafting methods and microcontrollers for the most seamless experience; c) Sewing together the placemat with sewable LEDs and a Gemma wearable microcontroller; and d) Seamlessly adding conductive thread to the wool to connect the pressure-sensing circuit with the sewable LEDs.

**Novel Interactivities.** The three artefacts engaged the senses using visual (A3), audible (A4), and tactile (A5) components. The Connectivity Candle (A3) used proximity-sensing and sound sensors to change the light colours and patterns of the candles, the Punch Concert (A4) used touch-sensing to change soundtracks, while the Party Placemat used pressure-sensing to change lighting patterns twinkling on the crafted placemat. The novelty is not in these interactions individually, but in the coherent theme of engaging various senses in a tactile and ambient way and the well-crafted efforts that are embedded seamlessly within everyday homeware things. Similar to how D1 spent days experimenting with essential oils to get the right combination, D4 also spent days concatenating songs and sound tracks into a dozen of long playlists to compensate for the limited 12 sensing inputs on the available microcontroller board. The playlists were creatively chosen by D4 such as ocean waves, outdoor sounds, or restaurant noise of utensils and people chatting in the background.

The ‘Together Apart’ concept in this study inspired new interactivities where synchronous and asynchronous interactions took place remotely across pairs of households. The idea is that one of the two connected pieces interacts (produces colour, sound, or light) through interaction with a member of the local home, while the other reacts in response to the interaction of a member of the distant home.

**Reflection.** This study focused on the designers’ experience of their critical making (as with A1) and fiction in critical speculation (as with A2), where Designers D3-D5 reflected, articulated and documented their design process. From the designers’ reflections, we were looking to get a deeper understanding of how interactive decorative COVIDware could be perceived and interacted with by users.



The Connectivity Candle was designed to create alternative forms of connection present as a peripheral display without being focus-demanding like smartphones. It was a decorative item that could be seamlessly added to a dining space without any signs of electronics or wires extruding from it. As for A2, D4 felt that the Punch Concert “*set the mood*” for when she is dining. The design process of the Punch Concert included crocheting a granny circle, which revived childhood memories for the designer. Likewise, the Party Placemat reminded D5 of her childhood, when placemats were frequently used during family holiday meals: “*This brought on a wave of nostalgia and memories of big Thanksgiving dinners. It also prompted a mental note to call home soon and check in with everyone*”. Furthermore, D5 noted that the artefact could formalize mealtimes and make them “*a dinner party for one*”. D5 also reflected on how this artefact would make the user more presently available during dining, transforming dining from being merely a secondary task, to being an experience that needs to be appreciated. Besides being mindful towards dining, the Party Placemat could add “*whimsy and excitement*” since “*Dinner [was] often rushed. It is a task you must complete before moving onto the next one, especially when time is tight to get something done by the end of the day*”.

## 6 Discussion

In these studies, our designers engaged with us in exploring what interactive homeware designs could act, look and feel like when designed for the context of a pandemic. Living in isolation from loved ones for the long-term creates new challenges to the wellness of people, their stress levels, and their sense of connection and perception to/of others. Yet in engaging with designers and observing how they visualize and/or tackle such challenges, we gain the richness of their array of designed artefacts as well as a deeper understanding and reflection on their design process. By analyzing these projects, we aim to shed light on opportunities for designing interactive homeware, contributing to a wider discussion about the role of everyday domestic decorative things in design-led HCI research. Having reflected individually on these studies, we will --- in this Section--- discuss roles that emerged across all three. Drawing from Odom’s Theoretical Framework [46] of perspectives as factors for our analysis, this section unpacks all three studies to try to understand why designers made these particular artefacts, how they made them well aligned yet individually, and what values, functions, and forms they unintentionally cross-used.

### 6.1 Function

When examining all five artefacts (A1~A5), it is apparent that the designers’ inner driver that shaped all of them was not to enhance productivity or efficiency. Yet instead, they are all designed for *connection* with the motivation to visualize a sense of communication to the outside world (A1), visualize the dis-connection from others (A2), and *engage* with others (A3, A4), or with self (A5). This added dimension was enriched with tangible artefacts instead of the commonly used screen-based

technologies for communication [20,57]. Despite being an artwork, the A1 and A2 artefacts were to be placed in a living room where they would be frequently seen. The tableware can be used on daily basis for eating with remote family/friends. Interestingly, some artefacts were not only designed for synchronous communication (A3, A4, A5), but for asynchronous interaction (A1, A3) as well as ambiguity (A2).

## 6.2 Symbolism

Despite the designers' personal creation of their designs, with no influences or engagement across the three studies, they all had the same aligning meanings associated with their designed artefacts. The five designs represented ---directly or indirectly--- meanings around loneliness, shyness, curiosity, and anticipation. Loneliness and shyness were most prevalently described and discussed in Monaxia, as the Koi fish were metaphors of lonely individuals, each enclosed in a separate frame. Curiosity and anticipation were dominating the user experience in 'Together Apart', as the designer anticipates the next song that will play. These representations all have deep metaphorical meanings that symbolize deeply felt or missed experiences during the lockdown. All designers also reflected on the cultural symbolism of their designs or their design process. For example, A1 was designed to reflect cross-cultural unity with Asian/European inclusion through the painting techniques while A2 was designed to reflect global tensions and disconnectedness (through ambiguity) while visualizing potential pleasing harmony (through Koi flow and colour-change). Inclusion and culture were also represented by the design processes of hand-crafting methods (e.g., brush-painting A1~A3, punch-needling A4, and crocheting A5) and the naming inspired by Chinese (A1) and Greek (A2) terminology. Using these methods or names themselves is not inventive, but the fact that designers resorted to symbolism in their designs using these statements does form an implicit message.

## 6.3 Augmentation

The kinds of designs created by our participants in this study had the power to extend its capability and purpose beyond its common intended use, mainly due to augmentation. Despite all being common household items, each crafted artefact formed a statement of creative expression highlighting the potential to empower people with more than their aesthetic existence in their homes. Artefacts included a carefully crafted artwork augmented with smell interaction (A1), a three-piece wall-painting wirelessly communicating together and responding to touch-sensing with colour-change (A2), a pair of light-candles in two different households interacting with each other through proximity and sound-sensing (A3), a pair of punch-needled media player that respond to yarn stroke with different audio feedback playlists (A4), and a home-made placemat crocheted with embedded e-textile lights that respond to pressure-sensing of tableware on top (A5). Generally, these objects were characterized by their designer's developed design concept and all included existing everyday domestic things augmented with interactive capabilities beyond their original purpose. This process relied on the varied amateur design skill sets and creative intuition of designers to resourcefully complete

such augmentations. Although most of them designed single-purpose functional objects and utilized simple user-input (e.g., tactile, sound, motion), the play-of-possibilities in the output interaction (e.g., visual, audio, olfactory, haptic) created a multi-sensory engagement that can be developed further when envisioning the trajectory of increasingly sophisticated technical applications.

#### 6.4 Material and Aesthetic Qualities

An unexpected finding in the analysis was how much all the designs, or how designers described them, lent themselves to be aesthetically nature-inspired. The only constraint designers had was to design COVID-related homeware. Yet interestingly, without ever communicating together as each study was entirely separate from the others, all participating designers inspired their designs from nature and natural elements. Mountain views (A1), koi fish underwater (A2), floral patterns, and earth-toned colours (A3, A4, A5) all have biophilic design elements to them. A1 also used the tactile feel and look of dried plants and moss as well as the mix of rain-forest, wood, and florally-scented essential oils to create “*earthy and muddy smells*” (D1). Similarly, A2 used the Koi fish spiraling inward design as a metaphor for elements being in natural harmony orbiting together.

Designers of A4 and A5 also reflected on the choice of yarns, its colour and thickness, the choice of needles and hoops, and the tightness and missed stitches. Their lengthy description of such details indicates the significance of ‘how will it look like’ to them as they were designing their artefacts. While other studies produced functional co-designed artefacts that are Low-Fi or not aesthetically polished, this study yielded pieces of home decor that are relatively well refined. Their detailed accounts of why and how they paid attention to such execution demonstrate the importance and value of aesthetic and material qualities when the artefact is meant for: being part of the home, reflecting felt or missed values, and enriching occupants’ experience.

### 7 Design Opportunities

We conducted brainstorming and reflective sessions and we have described the five artefacts individually (in Section 3) and collectively (in Section 4) in terms of function, symbolism, augmentation, material qualities, and aesthetic qualities as perspectives of examining everyday interactive things. Through a reflective brainstorming session among the research team, we peeled deeper layers of understanding ‘what did we learn?’ and ‘what are the key takeaways?’ of this project. For researchers and designers who want to design and build interactive homeware (or *COVIDware*) to be used in self-isolation, our interpretations of this research’s findings suggest several design opportunities worthy of continued investigation as follows:

## 7.1 Biophilic Design

The most prominent principle that all artefacts followed was the biophilic nature of the design. Even though none of the designers collaborated during the making phase, their designs were all predominantly inspired by nature. (A1) painted a landscape that was framed with grass, while (A2) drew inspiration from the Koi fish shot in the water. All other artefacts (A3–A5) were also inspired by the organic forms and colour palettes of nature. Several elements were used in common between the three artefacts, all indicating that COVID and its inevitable consequences have led to bio-starvation for those isolated at home for long periods of time, steering designers to enrich the artefacts with what COVID has degraded. We may increasingly start witnessing more utilization of biophilic design within interactive everyday things to compensate for their lack in our daily lives and appropriating its unique design elements. Herein, we unpack some of the biophilic elements we found across our COVIDware artefacts including imperfection and interactivity among other design qualities.

## 7.2 Imperfection

In nature, we typically would not find a perfectly symmetrical, evenly spaced, and evenly shaped/numbered leaves on a tree. We usually distinguish what is artificial from what is natural by the organic, imperfect look of it. Imperfection is also known to give hand-made artefacts some of their value as opposed to mass-produced products. We noticed that some designers employed this notion intentionally (e.g., D3 burnt the tip of the candles with a soldering iron and scratched the painting sponges) while others did it inadvertently (e.g., iteratively learning to 3D-print an intertwined piece, mix thermochromics with oil paints, or crochet with conductive thread). In the process of learning-through-making, designers intentionally want an imperfect look to the final product as it gives an authentic, natural accent to it. Such imperfection can be observed in the textured hues on the candle (A3), skipped stitches of the crochet (A5) and punch-needling (A4), on the randomly placed grass around the landscape (A1), and even on the unequal dimensions of the 3 canvases of (A2). Moreover, room for creativity and authenticity emerges in areas where a designer fails to achieve the perfectly desired features to an artefact, bringing us closer to the imperfections and variations of nature.

## 7.3 Interactivity

Another common theme followed by all designers (A1~A5) without collaborating to do so was the element of employing unconventional interaction and incorporating multisensory interactivity. Since people are staying at home more than ever before, they are looking to compensate for their interaction with the world by interacting with homeware using tactile, visual, auditory, and olfactory senses. This allows exploring different ways to interact with everyday objects, whether it's a placemat, a candle or a painting. For instance, adding smell interaction to a painting or tactile touch-sensing to a textile wall-piece are means of life-form interaction. These findings tie well with the concepts of slow design [17] and calm technology principles [67] that advocates against

prompt interaction and focus-demanding screen-based technology. The use of self and right-paced interaction along with multisensory peripheral attention of users supports users' adoptability and appreciation [46] rather than being intrusive in people's lives [37].

Home decorative elements and paintings are commonly created and owned for visual stimulation and contemplation; one would rarely think of interacting with a painting by touching, stroking, or poking it and receiving a response, as we do with living things.

Although the design research community has been working on relevant artefacts [42,62], there has not been enough focus on engaging the senses with the aim of expressing the continuance of life. Researchers often get carried away with technical constraints and challenges of building artefacts that they might overlook simple yet inviting interactivities. For example, the moss falling out of Liya (A1) caused a sense of expanding interaction ---beyond the interactive frame--- as if the artefact was growing with home occupants and interacting, not only within the 3D space but also, over time. On the contrary, it is quite intriguing to find designs that reflect biophilic and flourishing elements during a pandemic as it massively contrasts with illness, number of cases, and death. Or maybe that was the point? As we explore the addition of interactive everyday artefacts, we allow for new, unexplored ways of interaction.

## 7.4 Materiality

**On Materials.** Mediums ranged from oil and water colours for paintings to wool yarn for knitting and PLA filament for 3D-printing. Along this wide spectrum of mediums used, they all shared a physical aspect that supported deformation, creativity, and texturing dynamic surfaces [68]. The designers have eliminated the need for screens and thus the COVID screen-fatigue experienced by the prolonged lockdown and at-home stay while keeping communication with nature or people available. Unlike commercial electronic gadgets, designers opted for traditional mediums with electronics seamlessly embedded within them aligning with literature on this aesthetic value [29]. This allows for the seamless blending of aesthetically pleasing artefacts that are tailored to each household [42]. That way, people can surround themselves with more communicative biophilic spaces but without the need for an environmentally detached screen.

**On Form.** Each designer used inspiration from nature to create the form and shape of the artefact. The candle (A3) took on the intertwining shape of the trees, organically spiraling around and onto each other, giving the sense of symbiotic relationship found in nature. Similarly, the floral (A2, A4) and grassy (A1, A5) form of other designs are common aspects we only realized while analyzing all the artefacts together. Such biophilic design elements are part of well-established works in art and architecture [28]. However, we are yet to see the adoption of such notions when considering the design and form-factors of our interactive artefacts.

**On Colour.** The tones that were utilized by all designers were mainly of earthly hues, connecting the artefacts further with nature and emphasizing the concept of biophilic design in a household. The tableware (A3~A5) colour palette was intentionally chosen to be of a green hue, the painting of the Koi fish (A2) had the green element in the leaves floating in the pond, and the landscape (A1) had a grass frame. This can be caused by how the lockdown has detached people's lives from nature's spectrum of colours, leading to deprivation in the elements of nature in households. With the added hues of nature, the artefacts do not only work on a functional level to allow for connection with other people but are also placed as a reminder and a portal to nature and scenery beyond one's home. We are not suggesting that interaction designers should start creating their artefacts in biophilic-inspired colour palettes. Instead, we are advocating for considering the materiality of an interactive object given its interactivity and context, even when designing by/with novice users, or utilizing rapid prototyping techniques. Moreover, the use of colour-changing pigments (as with A1 and A2) also helps add aspects of time and colour rhythm enriching the materiality of aesthetic peripheral interactive artefacts [10].

## 7.5 Connectivity

Although each designer was working alone without ever meeting any of the others in-person, we eventually realized that they collaborated indirectly with each other through collaborating with the same set of materials, tools, and literature. In general, science focuses on understanding how the world functions for solving problems, engineering focuses on utility and productivity, and the tech industry focuses on performance and profit. On the contrary, creative practices focus on expressive and reflective values that add richer dimensions to our humanity. Designing COVIDware in the time of a pandemic taught us that it starts with the necessities (e.g., toilet paper and face masks) and then quickly redirects to the human indispensable emotional and mental needs of connecting with the physical world and engaging with others. From our reflective brainstorming sessions, we noticed how designers' focus aligned with design concepts aimed for people's wellness, sense of self, togetherness, and social connection.

**Connection with the World.** As our study focused on creating things in the context of COVID (where almost all social interaction and communication became limited to the virtual realm) our designers focused on designing tangible things that connect them to the physical world. Previous work has developed artefacts to help engage with the world (while outdoors) for self-reflection [54] and self-care [49]. Unlike such work, our first study focused on connecting with nature while being entirely isolated indoors. Design opportunities for future work may include designing for the self-isolated or remote individuals to connect with their immediate community and/or their wider society (beyond gamification that only serves a subset of users and marginalizes others).

In addition to presenting the design process thoroughly, designers further reflected on the artefacts allowing deeper understanding and richer insight into how one would live with interactive artwork that supports connection between individuals and the

outdoor world in their indoor isolation. Our findings show how interactive artwork can support the wellbeing of people during lockdown by engaging the senses of visual and olfactory interaction to better connect together and to their missed surrounding environment. In-situ deployment and long-term studies should look into how people feel about the different forms of communication through COVIDware. Are they sufficient? Is it ever intrusive? Do they develop implicit ‘rules’ of how to communicate? And can this create a new form of connection for/with people with disabilities (e.g., visual or hearing impairment) who are remotely isolated?

**Connection with Others.** D1~D5 reflected on the artefacts they designed, resulting in findings around the value of connecting with remote others through a tangible form. Artefacts that support screenless interaction with others ---even asynchronously--- intensify the sense of togetherness and virtual co-existence. Social-engagement, particularly with loved ones, is essential when we are most deprived of. Designers in our studies created simple instances that materialize their sense of loneliness and need to be among others. For example, integrating lights in a placemat to feel a pleasant ‘party vibe’ or augmenting audio feedback in a wall artwork to hear ‘restaurant noise’ are examples of social-aspiring interactivity. The attempts of replacing physical engagement with social media or creating virtual social events through online platforms (e.g., [www.gather.town](http://www.gather.town)) during or after working hours continue to prove deplorable and more distressing than entertaining due to COVID screen-fatigue. However, tangible COVIDware can be a non-draining alternative with self-paced and less-demanding communication.

Still, further work should tackle challenging aspects of technology as well as the social limitations of such concepts. For example, with different relationships, how would COVIDware be utilized or exploited? What kind of tensions may arise from symmetric (e.g., friends) versus asymmetric (e.g., parents and children) relationships? Future work should unpack such deeper design opportunities and challenges where users can find new means of using and interpreting interaction.

**Connection with Self.** Findings from our studies highlight the significance and value to design for connection with oneself (A2,A5). This design value and opportunity align with the philosophical stance of ‘Designing for the Self’ [69]. Interactive artefacts in general ---and COVIDware in particular--- not only can support self-reflection [29], self-care [36], or self-expression [51] but have this great potential to support *self-connection*.

Our second study (Monaxiá (A2)) showed how artefacts can visualize rich metaphors of people along the isolation spectrum living in separate frames yet striving as a community together. In that, designer D2 attempted to project their modes of interaction, which are restricted in portrayal to the sense of shyness, isolation, and introversion to the viewer through interactive artefacts. By fabricating three paintings to emphasize user characteristics of some individuals living through increasing self-isolation phases, the three wirelessly-connected artefacts reflect how different people socially respond to a global crisis. The use of *ambiguity*, *calmness*, and *slowness* as metaphors also support people to connect with their inner self. The communication among the three canvases and with the observer is ambiguous in a way that reflects

human's confused detachment from the natural and physical connection. Social interaction with virtual others around a culturally-diverse group ---with a lack of body language--- evokes exposure to the uncertainties and ambiguities of interaction.

The Party Placemat (A5) also shows the values of designing for self-connection and creating a sense of self-worth. D5's design reflected how valuing oneself is the vital internal sense of being good enough and worthy of (self-)love even if a person is not able to feel belonging or engagement with others. Self-worth is often correlated with self-connection, which can be supported through technology carefully designed to eliminate focus-demanding features. For example, social media is designed in ways that often increase feelings of inadequacy, dissatisfaction, and isolation. Contrary to that, we ---as a design research community--- should be designing for *self-connection* by addressing "how can self-connection be designed moderately without transforming into neither another form of isolating nor stressful self-doubting technology?"

## 7.6 Wellbeing

**General Wellness.** Instead of attempting to solve some engineering problem (such as how to increase performance while working/studying from home, or how to design an efficient device to do so), all designers created for their wellbeing through togetherness and self-care. Their motivation was to visualize a sense of connection to the outside world (A1), visualize the disconnection from others (A2), and engage with others (A3, A4), or with the self (A5). All their designs addressed feelings of loneliness, laziness, shyness, and longing for engagement with the world. These feelings and the metaphoric representations of their projected design decisions all reflect deeply felt or missed experiences during the lockdown. All other designers also expressed relevant notes on how their stay-home isolation negatively impacted their mental wellness [61].

To address this lived experience, designers created artefacts that incorporate multisensory interactions including visual, audible, tactile, and olfactory input and/or output feedback. Such interactive modalities did not only help them in improving their mental wellbeing, but also align with relevant studies showing the health impacts of reduced exposure to nature, interaction with others, and loss of indicators of time [2,4] where people miss touching, seeing, hearing, and smelling the world. These design concepts also tie well with previous work on how such challenges could be tackled through multisensory interaction (including audio feedback [43], colour-change [10], and smell-change [23,33]) and enhance the overall wellbeing [32]. Therefore, if we aim to design for users' wellness, we should be designing more of such senses-engaging modalities, and less of buttons, screens, and motorized machine interactions.

**Reflection on Remembrance.** Beyond togetherness, self-reflection, and self-care, COVIDware designers also designed for mindfulness, remembrance, and appreciation to product attachment. Their experience while living with their artefacts unpacks some of the associated sustainable benefits of long-term use [46]. For example, a person longing for nightlife created an artefact for a solo dinner party (A5); a person missing going out for nature walks and mountain hikes conceived a painting of mountains that



emit nature-inspired scents and choose the nearby chair as the favorite spot to smell the memories (A1). Research has unwrapped designing for domestic memorialization and remembrance [64] in a rare insightful study in Japan. Still, as researchers state: “*there is a clear need for future work to expand to sites and practices elsewhere in the world*” [p. 10][64]. In general, researchers and designers prototyping tangible interfaces should be mindful that there are often meaningful memories, and nostalgia, that shape the (co-)creation of some designs or are created from interacting with them. Beyond the moment, designing for connecting with the past, the present, and the future is a significant value when designing in the time of an unprecedented pandemic.

**Living in a Fluid Space-Time Fabric.** The transition between different roles that people have while self-isolated (i.e., working and/or studying, eating, sleeping, and entertaining in the same fabric of space-time) creates irrefutable psychological mental load on them. Part of this was visualized in Monaxiá (A2) where design elements, when triggered, hide from other people or other things. Slowness and mindful interaction were also employed in some designs to parallel and invest the general mood of monotony.

Reflecting on the designers’ (A1 and A2) decision to use smart colours (i.e., thermochromic pigments) and endure such effort to mix them with oil and acrylic paints respectively, highlights both its materiality and interactivity values. This also aligns with prior work on methods of using colour effects on people’s wellness and using smart colours to design for wellbeing [10]. Although the colour-change of such paints is quite slow (compared to immediate feedback of LEDs for instance) and occurs gradually, it employs the philosophy of *slow design* which, when done right, leads to interactive products that support wellbeing [17]. Self-isolated individuals are mostly bound to their self-imposed schedules. Supporting people at their own pace (according to their sensory and social needs) and designing for slowness promotes well-being for individuals, society, and the natural environment [17].

Furthermore, some designers highlighted the lack of separation of their public/private space and time. Now that the workspace can be the same as the living space, they can’t get away from either, and the lines between work and life becomes blurry [61]. The public and private got mixed into one when many communities shifted to home, so the challenges of COVID are not always *isolation*, but also the user’s inability to separate the public from the private and work from rest. If researchers want to design and study COVIDware for the context of working-from-home, they should carefully consider scenarios in which users might not want to interact with their artefacts.

In table 1, we summarize how each study inspired the design opportunities presented above.

**Table 1.** Summary of Design Opportunities

	<b>Study 1</b>	<b>Study 2</b>	<b>Study 3</b>
<b>Biophilic design</b>	Landscape and grass frame.	Pond, with water lilies.	Organic forms and colours.

<b>Imperfection</b>	Randomly placed grass.	Unequal dimensions of canvases.	Burning the tip of the candle, skipped stitches of crochet.
<b>Interactivity</b>	Moss falling out of frame.	Encouraging touch and feeling of the painting.	Touching punch-needle wall-art.
<b>Materiality</b>	Grassy form and texture.	Floral form and natural hues.	Organic spiral of candles onto each other.
<b>Crafting</b>	Laser-cutter at a local Makerspace.	Acrylic paints and thermochromic pigments.	Use of domestic 3D printing.
<b>Connectivity</b>	Landscape to connect to the outside world.	The metaphor of community striving to live together.	Self-connection and self-worth through the placemat.
<b>Wellbeing</b>	Olfactory experience for remembrance.	Visualize disconnection from others.	Having dinner synchronously using the candle.

## 8 Conclusion

In this paper, we introduced the concept of COVIDware for designing interactive everyday things that support people living through self-isolation. We demonstrated our concept through three studies of homeware everyday things that can help people connect with nature, with others, and with themselves. The interplay between our three methodological strands of critical making, critical speculation, and critical engagement allowed us to engage with designers to design, build and evaluate an array of fully-functioning COVIDware artefacts. Our contribution opens up a new design space of interactive homeware that can support people in enforced or self-imposed isolation to experience screenless togetherness. In this paper, we thoroughly discussed the design concepts, crafting process, implementation, and critical reflection on each artefact including making, speculation, or user engagement. We peeled layers of data analysis findings through critical making methods and reflections, analyzing the results across a relevant rigorous framework, and finally brainstorming deeper reflection through focusing on opportunities for design and generalizable takeaways.

The COVIDware applications created in our studies conform with prior work indicating that slow and multisensory interactions can indeed have a positive impact on wellbeing [17]. Although promising, we are not suggesting this should necessarily replace the design of commercial mass-production but should parallel such designs more often than seen today. In this paper, we present three design studies in which we explored how slow, calm, and ambiguous design principles can be applied in the design of interactive homeware elements even during a crisis. Five instances are reported on

where the conditions for designing COVIDware are explored. The results led to a revision of the user experience goals we study and teach in HCI literature. The main finding from our studies is that we do not have to design only for usability and utility, but should also design for tangible forms of social-engagement, connecting with the world, and self-connection. The use of DIY-making methods is not just powerful because of the accessibility and empowerment, but because allowing users to create their own self-customized artefacts supports their wellbeing, supports deeper remote togetherness (through their created object), and meets their needs more effectively than imposed designs. Hence, the COVIDware concept can be used to create more ‘mindful’ interactions that stimulate positive user involvement.

We hope that the critical reflective reporting of our design research can be appreciated as an effort to better support diversified and inclusive design research in the HCI community. More generally, we hope that our concept and examples of COVIDware designs and design processes inspire further research on affective communication using interactive seamless artworks, homeware objects, and everyday things.

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