GlassIO: Long-Term In-Home Study of Hybrid Craft Through Interactive Stained Glass

Daniel Gagnon-King
iStudio
Queen's University
Kingston, Ontario, Canada
20dgk1@queensu.ca

Lee Jones
iStudio
Queen's University
Kingston, Ontario, Canada
lee.jones@queensu.ca

Alisa Gamayunova
iStudio
Queen's University
Kingston, Ontario, Canada
18ag6@queensu.ca

Sara Litwiniuk
iStudio
Queen's University
Kingston, Ontario, Canada
19sll@queensu.ca

Renee (Xinyu) Chen
iStudio
Queen's University
Kingston, Ontario, Canada
18xc26@queensu.ca

Alisa Liu
iStudio
Queen's University
Kingston, Ontario, Canada
18zl107@queensu.ca

Catherine Stinson
School of Computing
Queen's University
Kingston, Ontario, Canada
c.stinson@queensu.ca

Sara Nabil
iStudio
Queen's University
Kingston, Ontario, Canada
sara.khnabil@gmail.com

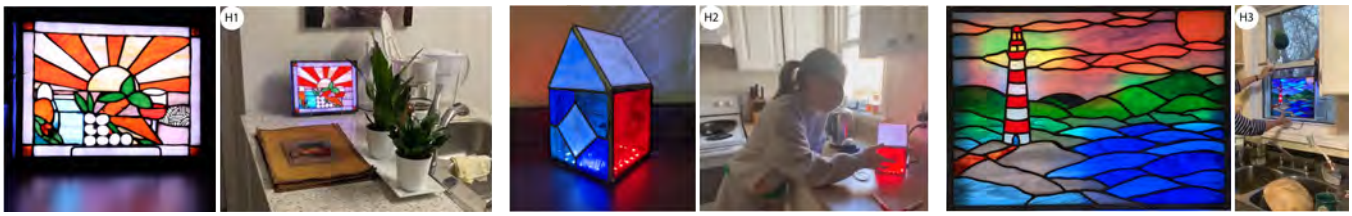

Figure 1: Our 3 interactive stained-glass artefacts that were co-designed with participants and deployed in their homes for our field study. (Left) SousChef: H1's installation in his kitchen. (Middle) MemoryHome: H2's installation in their living space. (Right) WeatherWindow: H3's installation on their window.

Abstract

Hybrid crafts blend traditional materials with embedded interactivity, yet everyday use of such artefacts remains underexplored. This paper contributes the study of lived experience with high-fidelity hybrid craft artefacts (made with interactive stained glass), following an initial study with 11 practitioners. We conducted three co-design sessions with nine end-users to create bespoke crafted artefacts deployed across three households for three weeks each, supported by user diaries and interviews. Our findings reveal how participants developed habitual patterns (placement, timing, relocation), emotional attachments, and disengagement needs, perceiving the artefacts as warm, expressive, and socially meaningful, distinguishing hybrid crafts from screen-based or smart devices. We offer design recommendations for leveraging artistic and pictorial qualities, supporting routine-based interaction and emotional connection, and designing for placement flexibility and spatial legibility. This work marks a shift from practitioner-only explorations of hybrid crafts toward user-centred in-the-wild understanding of how these artefacts function as lived-with technologies.

CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**; *Empirical studies in ubiquitous and mobile computing*; • **Hardware** → Emerging interfaces.

Keywords

Hybrid Craft, Domestic Life, Everyday design, DIY, Lived-with, Situated study, Internet of Things, Lived Experience, Fabrication, co-design, participatory design, Physical Computing

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1 Introduction

When interactivity is seamlessly integrated within everyday things, it supports more ambient [67], mindful and meaningful interactions [49], where the user forgets that they are operating a machine [57]. This paper explores how hybrid crafts (the blend of traditional craft practices with input/output interaction design) can be robustly deployed in real homes, beyond the studio or speculative designs. We present an in-the-wild study of interactive stained-glass interfaces (we call GlassIO), informed by practitioners workshops with 11 individuals, and in addition, co-designed and deployed with 9 participants across 3 households. Our work addresses a key gap in hybrid craft research by demonstrating how interactive crafted artefacts are lived with, and perceived as situated technologies in everyday environments.

1.1 What is Stained Glass?

Stained glass is an art and craft medium where pieces of colourful glass are cut and then brought together to create an image. The process begins with a design which is drawn on paper with each section labeled for the different colour [1]. A maker then cuts the glass pieces to match the design, lays them out, and solders them together to create the final artefact [1]. Unlike traditional glass that is looked through, stained glass is looked at. Rather than transmitting light directly, it transforms it through colour, cut, and assembly. Its metal joints create a sculptural, three-dimensional quality, and its look changes depending on lighting and position. These dynamic properties give stained glass a "kinaesthetic, kaleidoscopic aesthetic" [3] due to how it reshapes the atmosphere in a room. Historically, stained glass has ecclesiastical associations, such as in church windows and religious architecture, but it has also appeared in secular art and domestic spaces (particularly during the gothic revival and the arts and crafts movement [10, 54]). These uses reflected anti-industrial ideals and emphasized the artisan's hand in the final outcome [2, 54]. During this time stained glass expanded into homes to transform these spaces becoming more common in lamps, shades, and screens [3]. These qualities make stained glass a compelling craft material for exploring how traditional art can support interactive technologies in everyday life, as presented in our prior work [21].

1.2 Why Study Stained Glass in HCI?

Hybrid craft researchers are increasingly turning to the materials and artefacts already present in the home [45, 46] to inspire new forms of interactive technology [25]. However, existing work in HCI has typically explored hybrid crafts through one-off artefacts [8], studio-based case studies [68], or artist-in-residence collaborations [15], with limited end-user engagement and no in-home deployments [40]. In this work, we take the next step in hybrid craft research beyond engaging with practitioners: co-designing robust interactive stained-glass interfaces with end-users and deploying them in real homes for multi-week studies. Our aim is to examine how handcrafted interactive objects are lived with over time, and to capture insights that emerge from extended situated use.

Stained glass offers a rich and underexplored site for this inquiry. It is a sustainable material where some artefacts dating from the 14th century are still preserved to this day [22]. It is a widely practiced craft, accessible to both hobbyists and professional artisans, and ranges in scale from large windows to small, sculptural forms. While recent work in HCI has introduced fabrication techniques for embedding interactivity into stained glass [21], most interactive "glass-like" interfaces have used acrylics [19, 55], emissive displays [28], or imitation stained glass [41]. We build on this technical foundation by asking what happens when such a hybrid craft is used to build interactive everyday things with both sensing and actuating capabilities, and how are they lived with in everyday spaces?

1.3 Contribution

We created three robust interactive stained-glass artefacts using traditional fabrication techniques and embedded interactivity through touch sensing and actuation. These were informed by a prior set of workshops with 11 practitioners and co-designed with users. After prototyping, they were deployed in 3 homes for 3 weeks each, and evaluated through user diaries, pre-/post-deployment interviews, and in-situ observations.

Herein, our contributions to the design research and discourse of HCI hybrid craft and tangible interaction are:

(1) **Practitioner workshops:** In 3 workshops, we present the findings of engaging with 11 practitioners in both electronics and art to evaluate the applicability and considerations of prototyping with interactive stained glass as a hybrid craft.
(2) **Three co-designed artefacts:** Through 3 co-design sessions with users, we detail the creation of 3 real-world GlassIO prototypes that are robust high-fidelity hybrid-craft artefacts for everyday use.
(3) **Insights from the lived experience:** In 3 household deployments, we present a long-term situated study of interactive hybrid craft artefacts, and reflect on the findings of pre and post-deployment interviews, and user diaries during 9 weeks with 9 participants.

2 Related Work

2.1 Hybrid Crafts in HCI

Hybrid craft, or the hybridisation of traditional craft with computation, allows researchers to rethink the (often conductive) materials and the making processes involved in tangible interaction design. In a recent survey, Liu et al. [40] define two major strands of hybrid craft research: one investigates how computation can support or extend craft processes (e.g. digital fabrication in artisan workflows), and the other explores computational composites [62], where conductive or responsive materials are integrated into crafted artefacts. Several HCI projects have explored how conductive media (such as threads, fibres, pastes, paints, clays) can be embedded into traditional crafts. For example, Electronic Kintsugi [8] utilizes the traditional craft of using metal (gold) in its practice to repair ceramic works and to introduce interactivity. Similarly, recent literature started to propose the use of other conductive materials, such as goldwork embroidery [30], and metal tools such as crochet needles [52], as a means for hybrid crafts. These projects highlight how

hybrid craft brings computation into materials and practices with increasingly interactive elements to create devices that look like they belong in our home environments. Prior work has explored the potential of glass as a material for interaction and fabrication, including 3D-printed glass artefacts [20], laser-cut clear Perspex interfaces [19], interactive stained glass-inspired installations using LCDs [28], computational aesthetics for stained-glass rendering [17], and fabrication techniques for embedding interactivity into authentic stained glass [21]. SpectroFlexia[41] in particular explored smooth light transitions through translucent materials to convey peripheral information, illustrating how glass-like artefacts can act as both ambient displays and aesthetic objects. However, none of these works have engaged practitioners or users in participatory processes for the stained glass hybrid craft.

In parallel, the broader space of interactive materials research has developed techniques for crafting circuits using everyday substrates. Examples include hand-painting and screen-printing circuits on paper [11, 38, 59], textiles [6], and even biofoam [63]. These approaches support accessible, aesthetic, or situated forms of making, with conductive paint and conductive tape (e.g., copper foil [53]) playing a central role. Notably, copper foil is also foundational in traditional stained glass construction, offering an unexpected overlap between craft and electronics. Despite the growth of hybrid craft research in HCI, most studies remain at the level of one-off collaboration or small-scale practitioner engagement. Few projects have explored how hybrid craft artefacts are lived with, or how they function as enduring interactive objects in real homes. Our work addresses this gap by deploying robust, co-designed stained-glass artefacts for multi-week use in everyday domestic environments. To our knowledge, this is the first hybrid craft study to scale from studio and practitioner engagement to full in-the-wild deployments.

2.2 Living with Hybrid Crafted Artefacts

Our work builds on HCI literature that seeks to get a deeper understanding of lived experiences in home settings with prototypes of bespoke devices [36] or 'domestic Internet of Things' [12]. Longitudinal studies such as PhotoBox[48], Laina [42], History-Tablecloth [23], and Tilting Bowl[65] have demonstrated how interactive systems can support reflection, ritual, and meaning-making when lived with over extended periods. Similarly, Fenestra [61], Ritual Machines[36], and DayClo[39] investigated how artefacts integrate into daily routines when situated in real homes or workplaces respectively. While these studies offer rich insights into lived experience, many of them involved one-off prototypes crafted by researchers and tested with small numbers of participants, often in short or medium durations. Furthermore, technical robustness remains a key challenge in long-term field deployment, leading to (one of the reasons that) some researchers turning to autoethnographic methods as a way to manage ongoing repair and iteration during a study [24]. Our work contributes to this literature by combining robust fabrication, co-design with multiple participants, and multi-week home deployments. We also build on prior research that explores how users form bonds with crafted artefacts. Desjardins and Wakkary [13] examine the evolving relationship between maker and object during the process of living with a prototype, while Odom et al. [47–49] introduce concepts of slow and reflective design that support long-term human–artefact relationships. Our study extends these ideas to hybrid crafts by examining not only how researcher-designed interactive objects are used in-the-wild, but what happens when co-designed hybrid-craft artefacts are deployed and lived with in real households over time.

2.3 Participatory Design with Practitioners and End-Users

Participatory design and co-creation methods are widely used in HCI to involve diverse stakeholders in the development of interactive designs. Within hybrid craft research, there is a growing call to work with craft practitioners as design collaborators (particularly when the material, aesthetic, and cultural values of a traditional art are central to the work [7, 14, 16, 56]. On one hand, several studies have engaged with *practitioners* across a range of crafts (such as knitting [56], weaving [16], quilting [43], hand spinning [29], punch-needling [35], ceramics [8, 68], and jewelry [66]) to explore the tensions and opportunities of integrating interactivity into traditional practices. These collaborations not only surface deep material knowledge but also help navigate issues of material, cultural practices [29] and appropriation [8, 68]. Recently, there has been also a growing interest in HCI to develop artist-in-residence (AiR) programs with craftspeople, makers, artists, and STEM organizations, using these collaborations to generate new insights, learn from practice-based knowledge, and pursue open-ended ambitious inquiries [9, 14, 15, 60].

On the other hand, some work has explored participatory approaches with *end-users* for personalized and expressive artefact creation. For instance, the work on Wearable Bits [32] scaffolded the prototyping of e-textile wearables with end-users through the ideation toolkit 'Crazy Eights' [31]. Similarly, Shewbridge et al. [58] conducted in-situ studies of 3D printing with non-makers to understand personal fabrication in domestic spaces. These projects demonstrate how collaborative making with novel materials can empower participants and lead to personally meaningful outcomes. Recently, Jones [34] introduced a new form of hybrid craft (interactive bobbin lace) by both engaging beginner users and conducting an online interview study with practitioners from a virtual lace-making guild. While interactive stained glass has been explored as a hybrid craft in HCI, there are no prior participatory or co-design studies engaging with practitioners or users. Our work contributes to this gap by involving both expert practitioners and non-expert users through dedicated co-design workshops tailored to each group.

3 Study 1: Practitioner Workshops

We conducted 2 studies where Study 1 was with practitioners while Study 2 was with users (see timeline in Figure 2). Our first study was designed to explore opportunities and tensions for interactive stained glass with practitioners from art and technology, and to help us create our co-design kit for Study 2. We recruited 11 participants from both fields (seven electronics practitioners and four artists with an emphasis on stained glass practitioners) and grouped them together in a series of workshops composed of a presentation on interactive stained glass, an ideation session, followed by a group

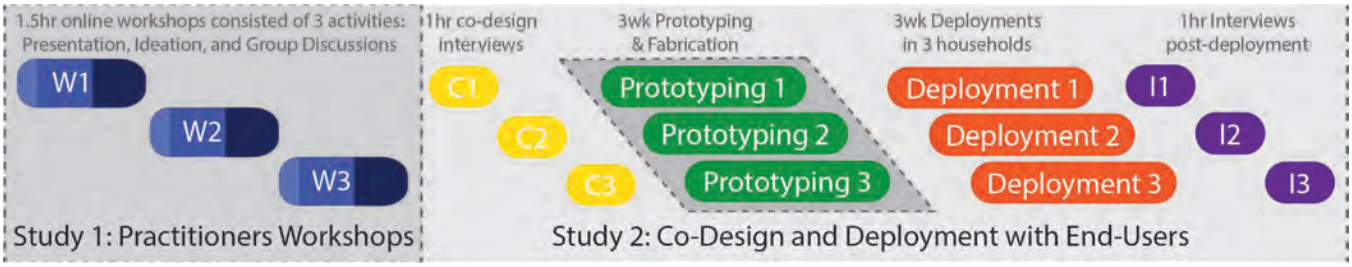

Figure 2: Timeline of both Study 1 and Study 2 similar to a Gantt chart format to show parallel and serial phases of the project.

discussion **(see participant table in Appendix A.1)**. The design of this initial study drew inspiration from works that employ a similar approach for researching hybrid crafts [7, 8, 30].

3.1 Practitioner Recruitment

The practitioner workshops were designed to be conducted online to gain access to a large group of potential participants (and due to COVID restrictions at that time). We recruited participants through social media posts on relevant online communities, by sending recruitment emails to mailing lists of students in computing, electrical engineering, computer engineering, and fine arts, and regionally using physical printed posters in artists' galleries, art supply stores, public studios). We prioritized the recruitment of artists with a background in stained glass as we are interested in gauging thoughts and opinions that traditional practitioners have on incorporating technology in their craft. This study received ethical clearance #blind-NUM from our institution.

3.2 Procedure

We used a combination of Zoom for video conferencing and a whiteboard software (Miro [44]) for visual ideation.

3.2.1 Presentation on Interactive Stained Glass. To introduce the practitioners to the workshop topic, the researchers presented a slideshow on Interactive Stained Glass (i.e. GlassIO) that included the fabrication process and techniques that leverage the conductive materials traditionally used in stained glass, as well as common tools between the two crafts (e.g., soldering irons, solder, copper tape, etc). We then presented samples and examples of this hybrid craft.

3.2.2 Ideation. The ideation group activity included a timed (15 minute) brainstorming inspired by a modified Crazy Eights [31, 37]. This involved participants ideating eight different ideas for interactive stained glass using prompts for each concept (an inspiration card deck with different locations, application areas, emotions, and user experience goals). Each group had access to a series of icons, emojis, and shapes that they could drag around the white board to illustrate their ideas.

3.2.3 Discussion on Opportunities and Constraints. Following visual ideation, groups were asked to choose one of their ideas and to refine it further with clear visuals and text descriptions. Participants were then asked to individually reflect upon the refined ideas by assigning each a rose (a positive element), a thorn (a challenge or barrier), and a bud (a new opportunity or potential) [27], given the prompt: "*If the idea were to be made, what would its designers have to think about?*". By refining and reflecting on their ideas, participants began to think critically about the potential applications of interactive stained glass. The discussion at this stage aimed to bring out the potential opportunities and tensions that interactive stained glass would create.

3.3 Data Collection & Analysis

We recorded around 4 hours of video interviews across all three workshops (1.5 hours each) and used automatic transcription. All transcriptions were verified with the video recordings and edited for clarity. Following data collection, the first author (both a stained glass practitioner and HCI researcher) performed qualitative analysis using the reflexive and inductive thematic analysis method [5]. This involved three phases starting with reading and initial note taking. The next phase was going through the transcripts and making line-by-line codes tagging the meaning behind what participants were expressing. These codes were then connected with relating codes to create subthemes and themes. During each of these three phases the notes, codes, subthemes, and themes were iterated on with the larger research team. Quotes throughout are prefixed with *A* denoting a participant with a background in the arts, and *E* for electronics practitioners.

3.4 Findings of Practitioners' Workshops

3.4.1 Stained Glass has Unique Interactive and Aesthetic Qualities. Participants discussed how the look of light through stained glass is less intrusive than other light-emissive displays due to the material characteristics. Soft animated glows of interactive stained glass were highlighted by participants: "*It's not as stressful [as a phone notification]. It's a little more toned down and a little less in-your-face stressful, hyperactive.*" [E1]. Similarly, others remarked on the visual appeal of interactive stained glass where it "*has a more ambient glow compared to a lot of the harsher LED lights you have today*" [A1]. Participants also discussed how the duration of a light notification could be longer with stained glass due to this calming glow, such as how stained glass is often used in overhead or desk lamp lighting.

3.4.2 Benefits over Screen-based Devices. Ideation was repeatedly steered towards graphical interfaces and how to implement them with stained glass as a hybrid craft. Some conversations discussed recreating "pixel grid" [E4] displays with stained glass: "*It's like you basically have small pixels, and depending on the colour value,*

Figure 3: Materials used for the co-design interviews include: stained glass samples (left), craft materials and grid-divided paper sheets for crazy-8s (middle); and colour-coded ideation cards we designed to inspire applications for different locations, function, form, and meaningful value (right) (see card deck prompts in Appendix B.2)

you have different images or different shades of colours that are lit up at different places" [E2]. Some stated the feasibility of designing a seven-segment display where:"*You could make any number. [...] that wouldn't be hard to do a stained-glass version either*" [A1]. Participants discussed the sustainability of the craft and its accessibility, highlighting permanence relating to stained glass' longevity and materials: "*It's more sustainable than standard decorations. It's glass, so it's probably better than plastic*" [E4]. However, participants also considered visual limitations: "*The main disadvantage with stained glass is unlike a regular screen, you're limited to one image. Unless you have a magic way to move the [glass] pieces around*" [E4].

3.4.3 Digital Norms Can Impose Concerns on Feasibility and Cost. One limitation brought up by practitioners was how stained glass traditionally plays an integral structural role in the built environment and where interactive stained glass would be feasible. Electronics practitioners were also concerned about the feasibility of creating their artefacts from both an engineering and a cost-effective (manufacturing) point of view. In contrast, artists were more excited by how this hybrid craft could shift the status-quo of design in technology that is: "*all about how to make it more sleek, how to make it cheaper for them to make as opposed to how to make it look nice. So yeah, I like that kind of bringing back some maximalism into it.*" [A2]. While electronics practitioners had some criticism of screen-based interfaces, they sometimes discussed how to make interactive stained glass as something similar to or comparable to screens. Some participants highlighted cost repeatedly indicating "*Is it cheaper than a standard seven segment display?*" [E4]. During group discussions, cost and production concerns surfaced again where some stated that "*[industry] is just going to resort to putting a touch screen in, because that's been the trend, but I guess that's not really the point of art [to mass produce].*" [E3]. Others were similarly concerned: "*I could see it more grow from the art side and develop in use case... because, as far as I think tech industry goes, they're just going to go with whatever is cheaper and easiest to make*" [E1].

3.4.4 Placements and Size Have Practical Limitations. Participants discussed multiple considerations to take into account when deciding where a stained-glass artefact might go in the home. A3 expressed that: "*One very popular place to put stained glass is in front doors, and you know, French doors.*" [A3]. As a stained glass practitioner, she also recognized certain properties and common appeals of the material: "*Light has to go through stained glass. So outdoors. Outdoors is a nice place to hang some stained glass. An interactive art display maybe?*" [A3]. This was echoed by E5 who was interested in the idea of artificial light and artefacts for walls in the home: "*So, maybe like a wall art. And then you can interact with the wall art*" [E5]. During the initial brainstorming activity, participants were not concerned about the size or placement of their artefacts. As ideas became more concrete over time, size became a concern: "*I think maybe I was thinking of [a large interactive pedestal], but I think it would [...] take up too much space actually*" [E5]. Rather than structural uses of stained glass, such as permanent window designs, practitioners ideated 3D objects and smaller-sized artefacts that are scaled down. For example, A1 suggested making artefacts such as everyday home objects: "*It'd be a neat little bedside table kind of thing.*"

3.5 Summary

The opportunities and tensions discussed among practitioners were used to inform our co-design and prototyping phases of Study 2. Practitioners identified stained glass as a materially-unique medium for hybrid craft, praising its calming, ambient glow as less intrusive than screen-based devices. While participants appreciated its sustainability and artistic value, they also struggled with challenging digital norms (as hybrid crafts normally do) and often defaulted to screen metaphors like pixel grids and segment displays. This tension revealed both the limitations of stained glass for dynamic content and the broader industry bias toward cost-effective mass-producible technology. Artists were more enthusiastic about hybrid crafts disrupting these norms by embracing aesthetic richness and permanence over efficiency. Practical considerations also emerged, as participants proposed scaled-down, 3D artefacts better suited to modern domestic spaces, expressing a shift away from architectural applications. This shaped our approach for studying the lived experience of this hybrid craft where we can (and should) reject techno-normativity, prioritize form and materiality, and consider the spatial realities of contemporary living.

4 Study 2: Co-design and Deployment

4.1 Participant Recruitment

Participants were recruited locally via posters and social media, with a focus on entire households and attention to age, gender, and household composition. We targeted households to study organic interactions with and through the GlassIO artefacts. Recruitment was limited to those near the university to enable in-person co-design, post-deployment interviews, and facilitate prototype delivery, pickup, and any adjustments needed during the deployment. This study received ethical clearance #blind-NUM and three households (9 total participants) signed consent, **see participant table in Appendix B.1**. Household #1 has a single occupant (76, male) who has occasional visitors (a grandchild and an adult daughter). Household #2 is a female undergraduate student household (each 21 years old) with 6 total occupants, 5 of whom were interested in participating in this study. Household #3 is composed of an adult couple (55, male and female), and a senior (83, female). While recruitment was targeted toward non-expert users in general, some participants had experience in either computing or stained glass. P1 is a retired business professional from a large technology company, P5 studies computer science at the undergraduate level, and P8 has some experience (and thus appreciation) with copper foil stained-glass projects. The co-designing sessions were conducted with the entire relevant household present.

4.2 Step 1: Co-Designing Sessions

A short presentation was given to participants as an introduction to interactive stained glass as a hybrid craft.The co-designing interview followed this presentation and started with a series of questions geared toward uncovering details regarding each household environment that would be relevant for the design of an interactive artefact (rental status of the home, preferences in art and décor). Further questions related to participants' previous experiences regarding stained glass in particular, and their preferences on aesthetics and functionality of home objects. This data was relevant to the study's desire to maintain a level of fidelity when creating participants' personalised home objects, according to their preferences.

Afterwards, participants received four sets of flashcards divided into the following categories: Location, Form, Function, and Value **(see card deck prompts in Appendix B.2)**. The physical flashcards replace the Miro board sticky notes we used in Study 1 and they were each provided with a blank piece of paper divided into 8 quadrants (one paper for each participant), see Figure 3. Once the timer was started, participants were asked to flip over one card from each category (four cards in total), and use the printed prompts as inspiration or guidance for their ideas, transcribed by-hand as both illustrations and descriptions on the paper sheets. We then gave them 20 minutes to come up with 8 ideas. Participants were asked to discuss their ideas, then as a household decide on which they preferred.

Although stained-glass samples were available during the co-design sessions, we also provided a set of glass-imitate magnetic building blocks to support rapid ideation with low-fidelity components while ensuring participants' safety from raw stained glass. Participants were encouraged to prototype as a household, such that the chosen form factor, design, and colour reflected the creative visions of everyone in the home. A group discussion followed the low-fidelity prototyping on various desired behaviours of the artefact to gain insight into what a high-fidelity prototype might behave like. Overall, the co-design sessions were designed to capture both participant's aesthetic design choices of how their devices should look through the sketches and physical prototyping, and functional design choices of how their stained-glass prototype should work and be interacted with through the prompt cards and storyboarding.

4.3 Step 2: In-the-Wild Home Deployment Study

After the co-design ideation sessions and weeks of prototyping, fabrication, and implementation, we conducted an in-situ study using the 3 different prototypes in their respective homes to address RQ2. In a 9-week deployment (3 weeks each), we collected data including system logs (recorded by each artefact) and user diaries (recorded by each participant). During the situated fieldwork, participants were able to interact with their artefacts in their own homes. The daily journaling method was used to see how the participants felt having the artefacts in their homes, and system logs were recorded each time the participants used the artefacts. Over the course of the deployment period, P1-H1 touched the SousChef prototype a total of 704 times (between both sleep mode enabling/disabling, and meal suggestion interactions). H2 participants touched the MemoryHome a total of 294 times (between recording, playback, and the stop recording function). H3 participants touched the WeatherWindow a total of 63 times (for cycling between 24-hour and 48-hour weather forecasting modes). All participants used Facebook Messenger to send daily journal messaging to the research team, and were messaged a reminder to send a journal entry if they had not send one in the past few days. After the three-week deployment, participants participated in a follow-up semi-structured interview. Major topics included: location of the prototype throughout the deployment, level of fit in its environment and comparing it to objects and devices in the vicinity, any barriers or challenges they experienced during the deployment, whether the prototype had any impact on their day-to-day life, any interactions with housemates or visitors in relations to the device, and any recommendations they have on improving the design. We then asked them to explain or expand upon events from their diary entries.

4.4 Step 3: Post-deployment Interviews

After each in-situ deployment, we arranged for the collection of the prototype from household members based on their time and location preference. Finally, the last step was conducting post-deployment interviews with each household. Each interview was attended by all participants of the household, at our lab, for around 60 minutes. All three interviews were audio-recorded, transcribed, and analyzed as below.

4.4.1 Analysis. Following data collection, we performed qualitative thematic analysis [5]. All quotes are used verbatim from the transcriptions and were edited for clarity by the first author. Reflexive inductive analysis [5] was conducted on the edited interview transcripts by the first and second authors using the MaxQDA Software [64]. The initial step in our analysis involved becoming familiar with the transcriptions by reading them through. Subthemes

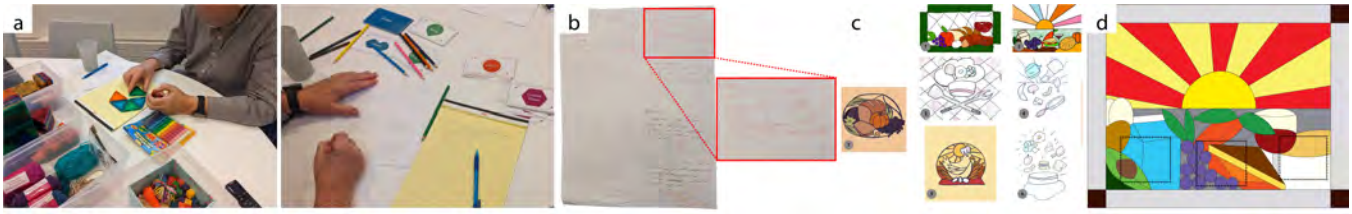

Figure 4: The first co-designing session where: a) P1-H1 during the ideation activity; b) wrote down 8 ideas of things he wanted and chose his favourite; c) we brainstormed together the design elements; and he chose his favourite then d) the selected design was identified with 3 touch-sensitive areas as a meal suggester (for breakfast lunch and dinner) in his kitchen (i.e., SousChef).

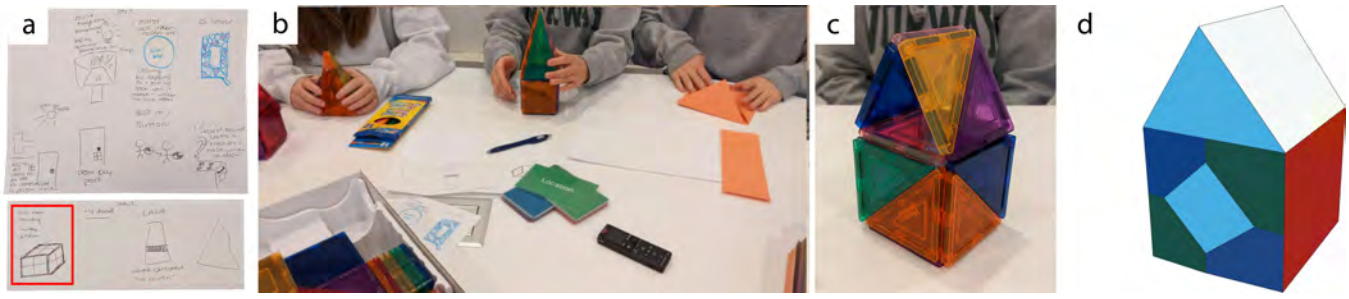

Figure 5: The second co-designing session where: a) P2~P6-H2 during the ideation activity; b) wrote down 8 ideas of things they wanted and chose their favourite; c) we brainstormed together the design elements; and they chose d) the selected design was identified with 3 touch-sensitive areas as a moment recorder in their living space (i.e., MemoryHome).

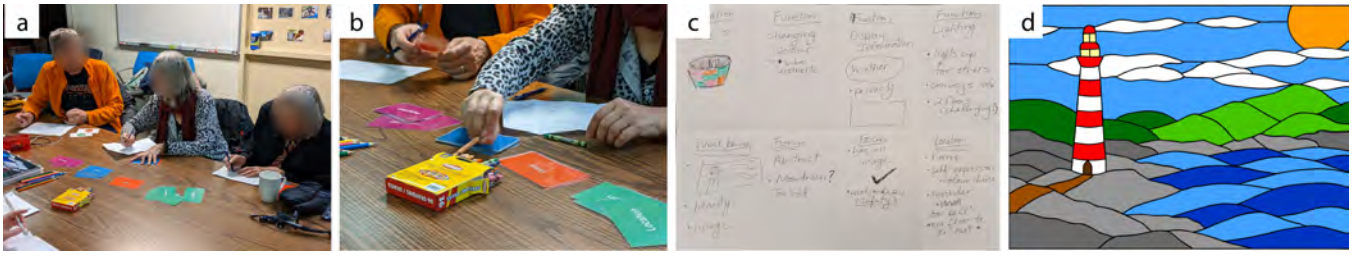

Figure 6: The third co-designing session where: a) P7~P9-H3 during the ideation activity; b) wrote down 8 ideas of things they wanted and chose their favourite; c) we brainstormed together the design elements; and they chose d) the selected design was identified as a touch-sensitive panel that displays the weather on their window that they wanted to hide for privacy (i.e., WeatherWindow).

and themes were determined using MaxQDA's Creative Coding feature, a tool that allows researchers to create visual tree-like connections between different codes. As a final step, the codes, sub-themes, and themes were reviewed and merged, removed, or kept as necessary. We include data extracts to demonstrate the codes.

5 Fabrication & Prototyping

After recruiting participants and conducting the co-design sessions with them, we started the fabrication processes to develop their low-fidelity prototypes into high-fidelity fully-interactive artefacts. To achieve input and output capabilities in glass (i.e. GlassIO), we used the fabrication methods published in our prior work [21]. Herein, we present details on the design concept (as established by the participants), the stained-glass design, and the implementation process. All high-fidelity prototypes were created using the copper foil method of creating stained glass as it is lightweight and versatile, affording us flexibility in our fabrication of these artefacts.

5.1 Prototype 1: SousChef

5.1.1 Design Concept. During the co-designing and ideation phase with Household #1 (P1), see Figure 4, the selected idea was for the designed artefact to manage food as a meal suggestion artefact. P1 preferred the following design requirements: there had to be interactions for each type of meal (breakfast, lunch, dinner), and an appropriate list of suggestions to draw from, which P1 later provided. The artefact would suggest meals randomly upon interaction (i.e., touch input) for the given meal time and would not suggest the same meal twice in a row. P1 was also concerned about the

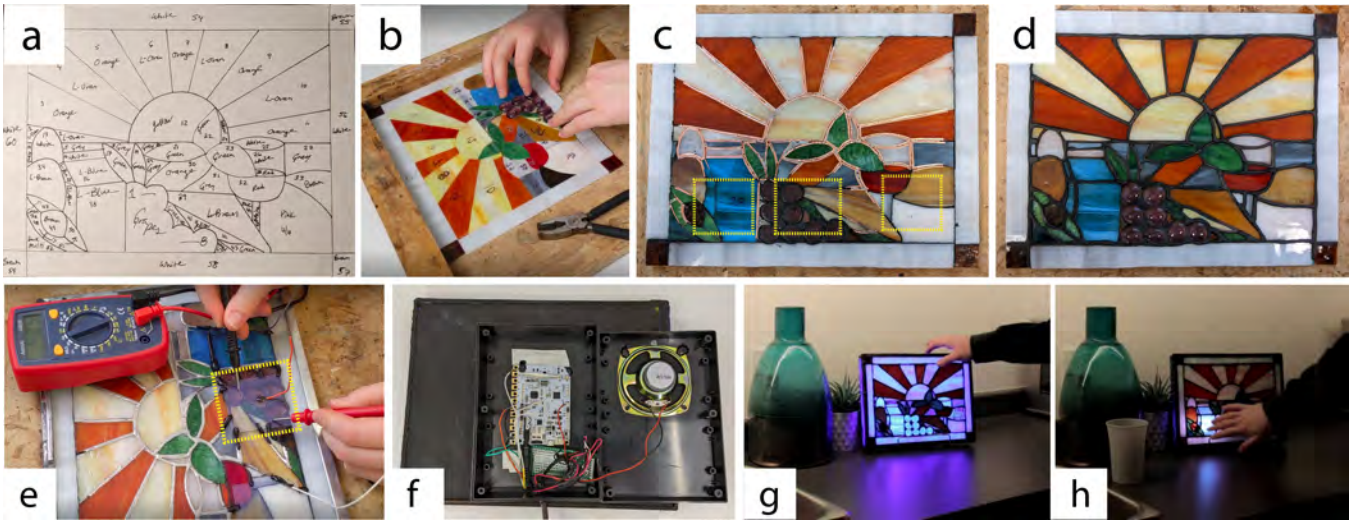

Figure 7: The fabrication process of the first prototype (H1) from: a) an illustration of the 2D design, b) assembling the cut stained-glass pieces, c) wrapping them with copper foil (except for touch sensitive areas), d) soldering the panel together, e) connecting the conductive glass, f) enclosing circuit, and g) final interactive artefact.

light actuation and was worried about brightness, considering that his bedroom was not far from the kitchen. As such, there had to be a fourth interaction to put the artefact in a type of sleep mode. We called this artefact the 'SousChef' since P1 (living mostly alone) described it as a kitchen companion, see Figure 7.

5.1.2 Stained-Glass Design. While co-designing the stained glass with us, P1 wanted *"kitchen-like design elements"*, such as a variety of foods, and perhaps a sunrise or a sunset. Each of the researchers created designs that were then passed through to P1 for selection. Considerations had to be made in order to reduce the amount of capacitive interference between the metal of the stained-glass panel and the capacitive touch electrodes. Our solution involves applying a black patina to the remaining solder of the stained-glass panel, and FlexPaste (a strong, black, silicone-like adhesive) in and around the areas where there would be capacitive touch electrodes. FlexPaste is messy and dries in a form that is difficult to control. Therefore, using the least amount of FlexPaste as possible is ideal (it should only be used for binding glass together). To achieve rounded channels that appear like solder with black patina, we used black hot craft glue on top of our FlexPaste joints and lightly sanded away the gloss to achieve a diffuse patina-like effect. The results are consistent with black patina to the point where discerning where solder ends and insulating adhesive begins is only possible upon close inspection.

5.1.3 Implementation. SousChef incorporates four touch interactions and two feedback modes. Three interactions let users select a meal (breakfast, lunch, or dinner) by touching the stained glass, and the fourth toggles sleep mode. The two feedback outputs include: 1) photonic outputs for indicating sleep mode (blue light) and for touch responses (highlight the section of the image corresponding to meal selection input), and 2) Audio output for meal suggestions and for announcing the mode (sleep/wake). We used NeoPixels and a PAM8403 low-power audio amplifier for photonic and audio output both controlled by a BareConductive TouchBoard microcontroller with a built-in MPR121 touch module and SD card reader/writer (for both audio files and system logs), all powered by a 5V adapter. We added capacitive touch electrodes to inert glass pieces using three pieces of ITO (indium tin oxide) glass. Attaching wires to glass was a challenge on its own, but we found copper tape behind opaque stained glass sufficient to secure connections with soldered wires. Despite all the conductivity challenges, we also used the top zinc frame as a touch-input electrode (to toggle sleep mode). We had to insulate it from the rest of the stained glass seams and keep it unsoldered to adjacent zinc channels, but FlexPaste it instead to account for the electromagnetic field circling the top frame. Using a long piece of metal as a touch sensor is generally risky in the context of interference, as the long piece acts as an antenna and will have a wider capacitive reach than a normal wide flat touch point. To account for this, we ensured that no other metals came within 1 inch of this top frame electrode.

5.2 Prototype 2: MemoryHome

5.2.1 Design Concept. Household #2 is composed of 5 participants (P2~P6), (see Figure 5). A routine that the participants from Household #2 engage in is leaving sticky notes around the house for each other that contain words of encouragement, jokes, or fun illustrations to brighten up the days of others. These sticky notes would occasionally be drafted as a group for another member to see, or for them to reflect upon individually at a later time. The household suggested incorporating this habit into their stained-glass artefact. As such, we co-designed a GlassIO artefact with them to remind them once a day to record, as a group or individually, a short voice memo (without providing the option to delete their recordings or alter them) and playback randomly later for reflection. We call this artefact the MemoryHome (see Figure 8).

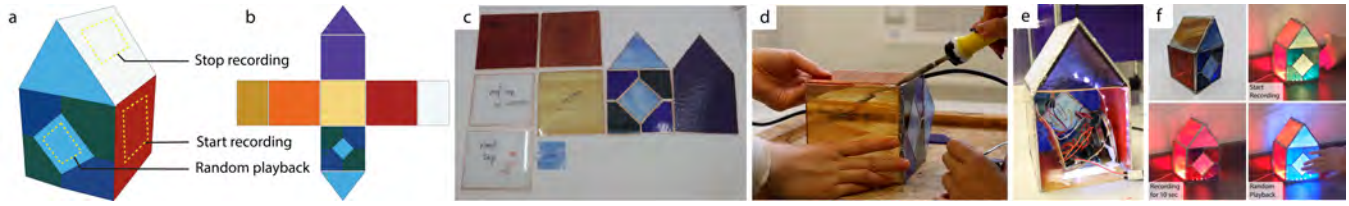

Figure 8: The fabrication process of the second prototype (H2) from: a) an illustration of the 3D shape, b) 2D pieces needed, c) to be cut from stained-glass sheets, d) soldered together, e) assembled with the inner circuit, and f) final interactive crafted artefact.

5.2.2 Stained-Glass Design. H2 participants resonated with 3D stained-glass objects and enjoyed the house-shaped design they created using plastic magnetic panels, appreciating its transparency and vibrant primary colors. While the size had to be increased between the low-fidelity and the high-fidelity prototype, we aimed to remain as faithful to their version as possible while making minor design modifications. Creating a 3D stained-glass object posed new challenges that we were not accustomed to while making stained-glass panels. The individual pieces for the walls, base, and roof were cut and taped as normal, but corner joints, for instance, had to be soldered at a perfect 90° angle to match the square base of the house, and a 45° angle for the pitch of the roof. It was difficult to achieve smooth solder seams and strong joints. Multiple layers of copper tape had to be applied to imitate a thicker tape, so the artefact would be strong enough to retain its shape over time. We created a back door for access to the circuit housed inside secured with metal hinges.

5.2.3 Implementation. MemoryHome features three glass touch points for starting a recording, stopping it, and playing a random memory. It provides feedback through audio playback, LED color changes, and blinking animations to display different states (i.e., playback, 24 hour reminders, recording, idle). We used an Arduino Uno controlling a DFRobot voice recorder, LED NeoPixels, and a speaker for playback in response to touch using Indium Tin Oxide Glass (ITO) as capacitive touch electrodes. Recording count was tracked locally on the SD card along with system logs. We implemented a recording time limit of 10 seconds as the recorder would record until its storage was full otherwise.

5.3 Prototype 3: WeatherWindow

5.3.1 Design Concept. All participants in H3 (P7~P9) enjoyed the notion of a stained-glass window indicating the current weather. They wanted their artefact to hang on a specific window, to incorporate the privacy element from their flashcards by blocking their neighbour's view into their home (see Figure 6). They specifically wanted their artefact to display the weather over time (i.e., current and next day) and suggested a specific stained-glass design with a seashore, hills, and a lighthouse, where the lighthouse could be used as a temperature gauge. We called this window-mounted panel the WeatherWindow, see Figure 9.

5.3.2 Stained-Glass Design. The WeatherWindow is a good opportunity to showcase the retrofitting of a traditional stained-glass panel for interactivity. As such, the stained-glass panel used in WeatherWindow is a traditional copper foil panel without computational additions other than turning the entire panel into a single, large touch electrode. WeatherWindow's stained-glass panel is large to accommodate the size requirements for H3's window (15x26"). WeatherWindow was not to block the entire window, but cover the bottom panel, and had dimensions of 14x11.5" which provides enough vertical room for hanging from the window's latches through a chain without the need for any renovation. The stained-glass panel's size was larger than other designs we had completed thus far, and our workspace was not well-equipped for this. As such, we used techniques from lead caming in order to improvise an adequate workspace. We did so by surrounding the panel's edges with horseshoe nails and flat-edged scrap glass to keep the panel at a 90° angle during fabrication, and rotated our workspace to provide more surface room to work.

5.3.3 Implementation. While the input interaction with this artefact is a single touch, the output consists of intricate animations that illuminate specific sections of the stained-glass panel to communicate various weather predictions. We created a capacitive touch sensor using a 1MΩ resistor that controls 252 NeoPixels arranged in a 12x21 matrix. To retain a flat form factor and be hung on a window, any electronics must fit within the 1-inch gap of the frame. We used the NodeMCU v1.0 microcontroller because it is small in size, powerful (to run the LED animation algorithms), WiFi capable (for fetching weather data), and powered by an ESP8266 chip which is compatible with the Arduino SDK. To make the stained-glass panel into a touch electrode, we soldered a single wire to a channel/conductive point on the panel. Since the zinc frame is also connected to the inner pattern, it is also touch sensitive as part of the same electrode as the inner design. We used JSON data fetched from OpenWeatherMap [50], a free-to-use weather API, every 3 hours to display changes in weather patterns and precipitation events. Additionally, it fetches the forecast for the following day (24 hours from the current request), and displays weather changes (i.e., increase/decrease in temperature) by animations along the stained-glass lighthouse (up/down). The final soldered circuit does not have a dedicated housing as with SousChef or MemoryHome. Instead, it is placed face-down along the transparent acrylic NeoPixel matrix casing that doubles as a light diffusion layer.

6 Findings of Living with Crafted Artefacts

Following reflexive and inductive thematic analysis (as described in Section 4.4.1), the results we found are presented in the below four key themes.

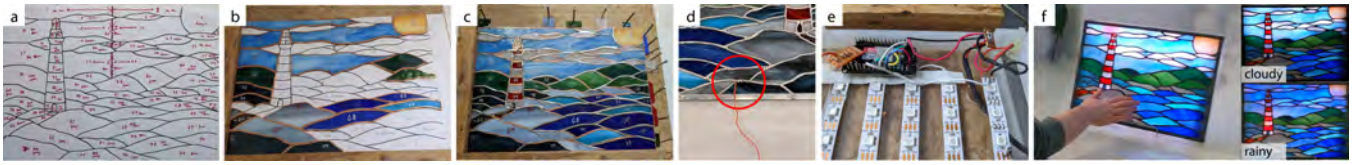

Figure 9: The fabrication process of the third prototype (H3) starting from: a) the paper sketching of the window panel, b) the 2D stained-glass pieces to be cut, c) soldered together, d) as a single touch-sensitive electrode, e) assembled with the inner circuit, and f) the final interactive crafted artefact.

6.1 Theme 1: Contrasting Digital Norms

6.1.1 Not a Screen: It Has Warm Ambience. The visual character of the hybrid craft artefacts was repeatedly highlighted as materially and emotionally different from traditional graphical interfaces. P1 explained: *"It's not like a computer screen. It has a life behind it"*. He expanded on how it lit up his home: *"It was just something that I found appealing, and it's the way it lights up"*. Participants appreciated that the artefacts contributed to mood and atmosphere even when inactive. For instance, H2 emphasized the artistic value even when not displaying information: *"I enjoy it as a piece of artwork in [our] home and the light that it gives off"* (P2). This made the artefacts feel emotionally expressive, unlike the cold glow of digital displays. P1 described how the gentle illumination became part of his daily happy moments, calling it the: *"friendly brightness"* that transitioned with the time of day.

6.1.2 Not like Alexa: It's Human-Centered. Many expressed unease with surveillance-based smart tech such as always-on voice assistants e.g., Alexa or Google Home. P1 said, *"I have a level of nervousness about, well, she must be listening because she knows when I say Alexa"*. Participants also contrasted their artefacts with these home voice assistants. They valued that their artefacts didn't track, judge, or broadcast their data. P6 in H2 captured this unease: *"I'm a very private person... I would hate it if it was recording all the time... I would get self-conscious about the number of times I open [and] close my drawer. I don't need that extra concern"*. This sentiment was common among different households. P7 in H3 said, *"Alexa is listening to you and ready for everything"*. Similarly, P1 in H1 also admired his artefacts saying: *"That's another good thing about it, by the way, it's not listening to me all the time"*. The voice features in our artefacts were locally stored and limited in scope. For instance, H2's voice recording had a 10-second timer that give users control and reassurance. P2 also commented on privacy and control expressing that: *"I got the experience of using an Alexa... but I didn't have to do the things that I wouldn't want to"*. Rather than being "smart" in the surveillance sense, these devices created warmth and trust. P1 said the voice on his artefact *"made a lot of difference to the sort of condescending voice of Alexa, or the robotic voice of a GPS"*. In the post-deployment interview, P1 described a growing connection with his crafted artefact because of that: *"I'm enjoying the Souschef, especially the design and the positive voice... [the artefact] has started to take on a personality of her own"*.. Although some researchers might regard the tone of voice as a software feature (secondary to the tangible user interface), it shapes the lived experience of users and is (in some cases) an integral part of the hybrid craft design. This care for privacy and emotional tone reflected a desire for mediated presence as a voice in the home, but not a judgmental or data-hungry one. P6 summarized: *"There's no higher purpose to this... you're not posting it anywhere... It's just here to be here... No one else is going to get a kick out of our recording except for us"*.

6.1.3 Not a Gadget: It Works as Art. Participants appreciated that the artefacts were not utilitarian gadgets overloaded with functions, but simple, dedicated objects that did one thing well. P1 said, *"You could put that display on an iPad, but... being its own artefact... was kind of a bonus, otherwise you'd be taking it away and using it for something else and then bringing it back again"*, appreciating that it offered one focused experience rather than multifunction overload. This simplicity was framed as comforting. Our participants highlighted the value that each artefact had when it wasn't conveying information or in active use. For example, H3 discussed what it was like to have the artefact in their home when the weather was the same for several days; *"then it works as art, which is great. It's still nice to look at"* (P7). H2 also discussed their artefact as a piece of art when it was not in use and that they *"enjoy it as a piece of artwork in [their] home and the light that it gives off"* (P2). This shows that, unlike gadgets and functional devices, a crafted object hold value for it's own right, even when temporarily or no longer operational.

6.1.4 Not an App: It's Much Nicer. All participants discussed an appreciation for the visualization aspects of the crafted artefacts beyond the function. As P8 summarized their weather artefact, *"It was a beautiful artwork too! Just lovely art, much nicer than the thermometer"* and *"weather on the iPad isn't as attractive as the weather on a work of art"*. Similarly, P1 *"people [would think] I could do that on my phone, I could do that on my iPad, but it's not the same thing"*. All of the artefacts our participants co-designed were sources of information that could have been retrieved with current smartphone apps (i.e., meal ideas, sharing voice memos, or weather updates), but conveying that information in a hybrid craft provided unique aesthetic interaction benefits. In this way, the stained-glass artefacts weren't filling an information gap, but rather transforming how that information was conveyed.

6.2 Theme 2: Forming Rituals Around Hybrid Craft Interfaces

6.2.1 Daily Rhythms and Timely Habits. Over the three-week deployment, participants developed rhythms and habitual patterns with the artefacts. P1, for example, described how his usage patterns evolved over time: *"changed during the first week, and then it settled down"* (P1). Initially, he checked it before each individual

meal, and then *"realized that really wasn't the best way to use it"*. By the second week, he planned all meals first thing in the morning so he could prepare for his day. As P1 described in his journal: *"I'm getting into a habit with the SousChef. First thing in the morning (well, after powering up the coffee maker) is to hear SousChef's cheery "good morning" and to get suggestions for meals. Especially for dinner since I'll probably need to grab something from the freezer"*. H3 also used their artefact in the early part of the day: *"You get up in the morning and see what the weather is like before you get dressed, and everybody who walks through the kitchen sees what the weather is like"* (P8).

6.2.2 Placement and Spatial Integration. Participants were highly intentional in how they placed and later repositioned their artefacts during the deployment period. These changes were often driven by a mix of practical, aesthetic, and social considerations. P7 explained: *"We placed it in a central location so you could reference it"*. P9 affirmed: *"Yeah, it was part of the routine"*. All participants started by placing their artefacts in the kitchen before shifting to the living space: *"It was more part of the living room than the kitchen"* (P1). For households sharing the artefact between multiple users, central placement made it more glanceable and accessible throughout the day. H2 participants checked the artefact during waiting times or between activities. As P3 described in her journal *"I have been listening to some of the voice memos when I have been in the kitchen making food or waiting for food"*. Initially, H3 placed it on their window to make sure it was visible as people passed by the kitchen in the morning (P8: *"everybody who walks through the kitchen sees what the weather is like"*). Importantly, it took the deployment period to build up these habits. As P6 describes: *"it becomes part of your routine once you've had it a little bit longer"*.

6.2.3 Portability and Relocation. All participants moved their artefact at least once during the deployment. These relocations often reflected a balance between visibility, usability, and aesthetic preferences. For instance, some participants modified placement to ensure the artefact looked good from key viewing angles. P6 noted that seeing the power cord detracted from the visual appeal: *"it was on a counter, and the plug was right here... then you wouldn't have seen all this stuff on the back"*. H3 also moved their artefact to face away from the ground floor window after noticing that their neighbour could see the backside from the driveway (P7: *"We finally looked at the piece from the outside. It looks industrial"*). They opted instead to place it against a wall so only the front was visible. Participants also moved the artefact out of caution during social gatherings. As P6 from H2 recalled: *"We had a party last night and so put it away because we were nervous about breaking it"*. This highlighted that the artefact, while cherished, was also perceived as fragile or precious and not suited to unpredictable group settings. In all cases, placement choices reflected the artefact's dual role as a functional device and a crafted object that was meant to be seen, shared, and protected.

6.2.4 Balancing Visibility and Calmness. While building routines with the artefact, our participants highlighted that it was also important to be able to build routines of not using, and turning off, the artefact. Our participants enjoyed the ambient light of the artefact, but said they would want to turn off the animations at certain times. These animations were described as *"very attention grabbing especially from peripheral vision"*(P8) and *"a little bit off-putting"*(P9). Throughout the three-week period they described moments where they wanted to "turn off" the notifications or updates after receiving them. P7 described this tension: *"There are times when it would be nice if we could turn off the moving lights for a more peaceful viewing experience. Other times, the dynamic nature of the 'moving lights' is engaging"*. In contrast, H1 had an artefact that included a sleep mode, where the participant could touch it and it would go to sleep (saying "Good night" and switching to a dim blue light). P1 described building up a routine of going through this action before bed: *"Good night, Emily [...] and toning it down to that nice blue"*. Similarly, H2 described seeing the light notifications on the house at moments of misalignment, such as just before going to bed. At the same time, especially in communal households, turning it fully off would result in individuals forgetting to turn it back on: *"we would walk away and forget that it was unplugged"* (P6). These reflections highlight that having a specific "sleep mode", along with being able to turn it off, are important designs to include with interactive stained-glass.

6.3 Theme 3: Hybrid Craft Meaning and Value

6.3.1 Offering Pictorial Information. Participants saw stained-glass as more than abstract art where it could be a medium for pictorial or icon-based information display. They expressed a preference for literal icons (e.g., weather symbols, food images) embedded in the stained-glass design, which retained its artistic quality while improving usability. P1 described it as, *"not like a computer screen. It has a life behind it"* and added, *"people [would think] I could do that on my phone, I could do that on my iPad, but it's not the same thing"*. P8 noted, *"weather on the iPad isn't as attractive as the weather on a work of art"*. Participants appreciated that these artefacts provided calm, ambient feedback, while still being information-rich. P7 advocated for more literal weather icons: *"In terms of function, I think it would be easier if we had a sun when it was sunny, snow, things like that"*. However, P4 said, *"There was never any guessing"* in reference to the colour-coded feedback of Prototype 3. Overall, we found that most participants (H1,H3) highlighted the value of "the pictorial design" as P1 described "it also fitted in for a nice bright start to the day".

6.3.2 Smart objects, Data Visualizers, and Reminders. Participant ideas reflected a spectrum of interactive artefacts and smart home objects where some envisioned *"system control"* artefacts. P1 imagined *"basically a kitchen helper... it would control the stove and the cooker... If there was a spill it would recognize that... also give some access to a database of recipes... punch up then it makes suggestions"*. Others imagined data visualization or representation. P5 suggested *"something that would somehow capture our last semester, even if it [is] just collecting data in some way. That could be meaningful"*. H2 occupants also discussed tracking moods, identifying who was home, or responding to decibel levels. Similarily, P1 proposed a scale: *"tell you your weight plus your BMI, skeletal mass,"* and joked, *"if [it] would be nicely put together so that the information wasn't so horrific as it normally is!"*. Reminder technologies were also common among the ideas that participants generated. P1 suggested, *"a panel... that would sit on the desk and would actually come up and*

tell you, 'you have this urgent thing to do'". P2, discussing ADHD, appreciated aesthetically pleasing reminders. H2 envisioned a tap-to-remind system: *"Reminder: 'you're forgetting something, tap to remind someone on lamp'"*.

6.3.3 Heartfelt Aesthetic, not Cold Functional. At the same time, aesthetics mattered a lot to participants and shaped their sense of adoption and product attachment. P1 said, *"People want to [even] personalize [their cell phones] with their own art"* and P6 wished for tech that is *"really pleasing and functional"* but she was worried about the high cost. P7 highlighted how aesthetic appeal is crucial to him and said, *"if it were ugly and I didn't like it on my counter then I wouldn't have it"* while P8 valued the endured cost of tech: *"if I had bought it and it worked I'd keep using it"*.. However, P8 also recalled an artefact he disliked in their summer home: *"We finally tore it down and every time I've been there, I'm just so much happier"*. In the deployment interview, P1 described his crafted artefacts: *"it was just something that I found appealing"*. This shows how beautiful, personalized and crafted things, compared to cold functional tech, can be more valued by people.

6.4 Theme 4: Emotional and Social Connection

6.4.1 Growing Attachment. Across households, participants described growing personally attached to their artefacts and developing relationships with them. In H2, participants were notably upset when their artefact was collected at the end of the study. They had referred to it affectionately (saying things like *"hello little house"*) and described enjoying its continued presence even when not actively using it. Similarly, P1 in Household 1 named his artefact *"Emily"* explaining that *"SousChef has started to take on a personality of her own. And yes, she is female"*. These personifications reveal an emergent social interaction, where participants began treating the artefact as a social other that is emotionally present even without needing reciprocity.

Participants also reflected on its social visibility in the home. H2 described hiding their artefact while having guests to prevent it from getting damaged: *"we had a party last night and so put it away because we were nervous about breaking it"*. Similarly, P1 described how his granddaughter invented a game with the artefacts: "You are a..." treating it as a playmate or performative object. These findings show how the artefacts elicited not only personal attachment but became a social actor with improvisational engagement in the home.

6.4.2 Response to Absence. Emotional connection with the artefacts continued after the study when participants described "missing" the artefacts once the deployment was complete. P5 described how engagement improved the longer you used it: *" Yeah, I was really sad [...] because the longer you have it, the better it gets"*. P3 described feeling down at not being able to say goodbye: *"I knew it was getting picked up yesterday, I saw the email, but when we were sitting outside on our front lawn when [researcher] came in and picked it up, and I was like, oh, I didn't say bye to it [makes a sad face]. It just left"*. P1 described his emotional response after deployment concluded: *"I miss her. I'll be honest.* These findings show how hybrid crafted artefacts are not only means of interaction and delight when present, but can provoke long lasting attachment and connection overtime with users, even when absent.

6.4.3 Nostalgic Relationship. Participants repeatedly emphasized how the artefacts felt authentic, personal, and even nostalgic. Many described valuing their single-function simplicity, comparing them to 'old things' that just do one job well such as *"analog camera"* (P6), *"intercoms"* (P2), or *"walkie-talkies"* (P3). As P2 summarized: *"It feels a lot more authentic, less curated... like you're talking to a can with a string... It just reminds me of my childhood"*. This appreciation intersected with the IKEA effect where users feel greater attachment to something they helped make. Because participants co-designed and had input on their artefact's function and form, they felt ownership over its presence. P1 said, *"It had a craftsman look about it... It was created, not made in a factory... I think that added to the value"*.

7 Design Opportunities for Deployable Hybrid-crafted Artefacts

Through the deployment of three different artefacts in-the-wild, co-designing with users, and reflecting on their lived experience with for three weeks each (9 weeks in total), we provide design opportunities for researchers aiming to deploy hybrid craft interfaces.

(1) **Treat Hybrid Artefacts as Both Interfaces and Art** The lived experience with hybrid crafts can bring in playfulness, joy (positive mood, warm ambiance, friendly interaction) and more importantly being more authentic and human-centred. Based on our study, users felt more confidence and deeper meaningful value of interacting with hybrid artefacts and perceived them differently from screen-based apps or personal assistant devices. This aligns with prior work [18, 42] that shows how the tangibility of interfaces supports the physicalization and visualization of information display. While the functional purpose could be similar to other devices, users appreciate hybrid crafts as works of art that is not only beautiful but has a life behind it and means much more for their own right.
(2) **Facilitate Routine-Driven Interactions** Crafted interfaces (like other forms of tangible devices) should account for interaction at meaningful times (e.g., morning routines, transition points, bedtime) to support lived-in integration. While we tried to include this in some of our designed interaction, it could be useful for every crafted artefact to be easily controlled. Future work can look into how to allow users to modulate the interaction level (such as light modes, sleep states, activation intervals) to fit different rhythms of use.
(3) **Plan for Portability and Placement Flexibility** It is important that we, as the HCI/TEI community, design hybrid crafts of daily use to be lightweight, stable, and portable, acknowledging how users move them to suit activities, social settings, and aesthetics. As much as we can plan these ahead of time (like we did in the practitioners workshops and pre-study interviews with users), these considerations also change in-the-wild from time to time. To accommodate household dynamics, designers should consider seamless designs, portability, wall-mounted options, and concealment of electronic components.

(4) **Leverage Pictorial Information in Hybrid Crafts**: While many craft-based interactive artefacts favour abstract designs, our findings suggest that pictorial representations (such as icons or symbolic imagery) can enhance clarity and engagement without sacrificing aesthetic value. Participants appreciated being able to interpret information at a glance through recognizable visuals (such as sun, cloud, and waves for weather; breakfast, lunch, and dinner images for meal suggestions; and red panel for audio recording) and several explicitly requested a richer visual iconography. This presents a unique opportunity for hybrid crafts to draw from UX icon lexicons to improve usability while maintaining their artistic presence in the home. Future work could explore how different visual vocabularies affect user understanding, attachment, and daily interaction with hybrid crafted artefacts.

(5) **Celebrate Single-Purpose Devices** While research has shown the value of many single-purpose artefacts [39, 49, 69] for daily use, commercial tech products are increasingly designed as multifunctional gadgets that collect and process massive amounts of data. Instead, we advocate for hybrid artefacts that have focused poetic interactions and offer emotional or meaningful value. Future work can draw inspiration from nostalgic metaphors (such as walkie-talkies, analogue devices, etc) to design new hybrid forms of interaction.

(6) **Prioritize Glanceable and Spatial Legibility** We learned from our study that not only we should design hybrid crafts that are understandable at a glance but also viewable at a distance to be suitable for home use. All our participants placed their hybrid crafted artefacts in central shared locations in the home such as kitchens and living rooms. We encourage researchers to account for this when proposing applications for hybrid craft home objects and to consider how sculptural design can support multi-angle visibility and how their proposed interfaces (and interactions) can adapt to domestic spatial constraints.

(7) **Engage Users as Co-Creators of Hybrid Crafts** Using co-design methods to let users shape artefact function and forms leads to stronger attachment, ownership, and perceived authenticity. Although the HCI literature has extensively praised co-design methods, we believe that it is particularly valuable for hybrid crafts more than other forms of interface prototyping since there is a greater emphasis on materiality and craftness. While there is some research [33] that engaged participants in hands-on co-design of hybrid crafts, participatory design of hybrid crafts is largely underexplored [4] it was mostly limited to practitioners or within context-sensitive demographics. Future work on hybrid crafts should focus on deeper involvement of users from different background and expert levels and celebrate the IKEA-effect where users' hands-on manipulation of the materials might not only generate more insight on what they want from technology but also enhance its perceived value.

(8) **Design for Emotional Attachment** Crafted artefacts can be inherently designed to support gradual bonding over time [51] allowing users to develop rituals, routines, and even emotional and anthropomorphic relationships (e.g., "Emily"). While HRI (Human-Robot Interaction) has looked into this, we argue that hybrid crafts can also be a meaningful source of social connection where users perceive its interactive artefacts as social actors. Future work should attend to the interaction repertoire (even the software programmed side) of tangible crafted artefacts such as considering how voice tone, visual presence, and tactility contribute to parasocial interaction.

(9) **Support Interaction without Surveillance** Although not exclusive to hybrid crafts, concerns about privacy and surveillance were dominant in our study. Users highlighted the need for non-intrusive interaction (e.g., local voice recordings, built-in data storage) that supports interaction without aggressive data collection or cloud dependency. We encourage the research community to maintain users' feeling of agency and privacy by limiting the exposure of their interactions (both explicit and implicit ones) to others (individuals or systems). While this point may seem generalizable across tangible interfaces, we include it here in good faith as it was one of the most valued features of our hybrid crafts, distinguishing them from smart speakers and commercial IoT devices.

(10) **Design for Disengagement and Quiet Presence** Alongside the routines of use and emotional bonding users develop, there's also a clear desire for intentional disengagement rituals. While prior work showed value for slow technology [26, 48], we advocate for de-interaction i.e. empowering users with ways to interact less or control a smooth transition of the artefact into a more ambient peaceful state when (not) needed. This includes features such as sleep modes, dimmed lighting, deactivation intervals, and temporary silence that respect changing moods or social contexts. Our study showed users' desires of a broader need for hybrid artefacts that support graceful withdrawal, not just active engagement. Since users' felt loss and missing artefacts after their removal, we suggest that hybrid crafted artefacts are like cherished objects (or companions) that require careful design for both presence and absence, helping users engage meaningfully, and also step away gently when needed.

8 Limitations

Among the limitations of this work is the physical scale of the artefacts that was relatively small due to practical constraints in fabrication time, safety, and material handling. Larger-scale installations, such as full windows or embedded architectural features, would require extended production timelines beyond the scope of this project. Second, the three-week duration of each deployment (while offering valuable insights) was relatively short. Longer-term studies could reveal further patterns of interaction and usage over months or years. Finally, our focus on stained glass as a specific material and craft medium might limit generalizability. While our findings highlight the potential of hybrid craft artefacts in the home, they may not fully capture the lived experience of other materials (e.g., textiles, wood, clay) that offer different affordances, meanings, and interactions.

9 Conclusion

This work advances the understanding of interactive hybrid craft through three strands of investigation. First, we engaged eleven practitioners across art and electronics in three workshops (Study 1), to highlight material considerations for working with stained glass as a hybrid craft medium. Second, through three co-design sessions, we developed robust high-fidelity artefacts shaped by user needs, aesthetics, and everyday routines. Third, we conducted three in-home deployments with nine participants over 9 weeks in total (Study 2), presenting a situated study of hybrid craft artefacts in-the-wild. These deployments revealed how such artefacts are lived with, re-situated, and socially integrated into domestic environments.

On one hand, Study 1 with practitioners helped surface some material and feasibility considerations of interactive stained glass. Those workshops highlighted the calming ambient glow of stained glass, practical concerns related to cost and permanence, and the potential of scaling stained glass into smaller, 3D, or wall-mounted forms rather than large architectural pieces. However, debating these tensions limited their group discussion and creative freedom where some even attempted to emulate pixel grids or seven-segment displays in stained glass, revealing an impulse to conform to dominant paradigms of interactivity. On the other hand, our findings from Study 2 show that hybrid craft artefacts are perceived as more than functional objects where participants perceive them as emotionally expressive, aesthetically rich, and fundamentally different from gadgets, apps, and smart home devices. Unlike gadgets, they were valued even when not in use, appreciated as art pieces with ambient presence rather than utilitarian tools. Unlike assistant devices, they fostered trust and comfort through single-purpose localized interaction without surveillance or judgment. And unlike apps, they offered a tactile and visually engaging experience that conveyed information through material charm rather than screen-based data displays.

Whereas practitioners focused on speculative ideation of what could be built, our household deployments show how these artefacts are actually lived with, revealing user perceptions, everyday interactions and sense-making. The transition from workshop to home shifts the discourse from feasibility to situated meaning, emphasizing hybrid crafts' distinctive qualities as quiet, expressive, and materially grounded alternatives to other forms of devices. Together, these two studies offer a fuller picture from practitioner insight on making and feasibility, to end-user experience in daily life. They demonstrate that hybrid crafts are not only technically viable, but socially and emotionally resonant when embedded in real homes. Finally, we contributed a set of design opportunities for deployable hybrid craft artefacts that include supporting emotional and social attachment, enabling routine-based engagement (and disengagement), and facilitating portability and spatial legibility. These recommendations move hybrid craft beyond the studio, demonstrating its viability for real-world use and its potential to shape everyday interaction in richer ways. Future work should expand this design space by investigating the lived experience of other hybrid craft mediums (e.g., e-textiles, interactive ceramics, paper-based computing, etc). We encourage researchers to embrace the challenge of co-designing robust, high-fidelity, and long-term deployable artefacts with end users to gain deeper insights into their situated real-world use over time.

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A Practitioner Workshop Appendix

A.1 Study 1 Participants

Table 1: Participant details for Study 1 (Practitioners Workshops)

Alias	Age	Gender	Background	Craft	Experience Years	Workshop
A1	44	M	Worker	Stained-glass	2	2
A2	32	M	Graphic designer	Graphic design	10	3
A3	56	F	Artisan	Stained-glass	31	2
A4	37	F	Art grad student	Stained-glass	5	3
E1	24	M	Engineering grad student	Electronics	5	3
E2	25	M	Engineering grad student	Electronics	3	1
E3	24	M	Mechatronics grad student	Electronics	5	3
E4	23	M	Computing grad student	Electronics repair	3	1
E5	20	M	Computing undergrad student	Electronics mods	2	2
E6	18	M	Computing undergrad student	Electronics	2	3
E7	22	F	Computing undergrad student	Electronics	4	3

B Co-Design and 3-Week Deployment Study

B.1 Participants

Table 2: Participant details for Study 2 (End-users)

Alias	Age	Gender	Household
P1	76	M	1
P2	21	F	2
P3	21	F	2
P4	21	F	2
P5	21	F	2
P6	21	F	2
P7	55	M	3
P8	55	F	3
P9	83	F	3

B.2 Card deck for co-design crazy eights

Table 3: The ideation flashcards given to participants during for co-design.

Location	Form	Function	Value
Home	Flat	Lighting	Aesthetic
Office	3-D	Displays Information	Wellbeing/Relaxing/Mindfulness
Bathroom	Pointy	Holds Something	Social Engagement
Window	Motionless	Locks	Recreation
Mirror	Long	Enters a Code	Memorability
Door	Short	Privacy	Self Expression
Table	Colour	Control Panel	Self-Reflection
Wall	Dark	Reminder	Productivity
Wearable	Light	Alert/Notification	Utility
	Opaque	Changes Colour	
	Transparent		
	Has an Image		
	Abstract		
	Light		
	Heavy		
	Miniature		
Example combination:	Wall - Light - Changes Colour - Self Expression		