TaskCam: Designing and Testing an Open Tool for Cultural Probes Studies

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ABSTRACT
TaskCams are simple digital cameras intended to serve as a tool for Cultural Probe studies and made available by the Interaction Research Studio via open-source distribution. In conjunction with an associated website, instructions and videos, they represent a novel strategy for disseminating and facilitating a research methodology. At the same time, they provide a myriad of options for customisation and modification, allowing researchers to adopt and adapt them to their needs. In the first part of this paper, the design team describes the rationale and design of the TaskCams and the tactics developed to make them publicly available. In the second part, the story is taken up by designers from the Everyday Design Studio, who assembled their own TaskCams and customised them extensively for a Cultural Probe study they ran for an ongoing project. Rather than discussing the results of their study, we focus on how their experiences reveal some of the issues both in producing and using open-source products such as these. These suggest the potential of TaskCams to support design-led user studies more generally.

AUTHOR KEYWORDS
Design Research; Cultural Probes; User Studies; Context Studies; Open Source; Making

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
TaskCams (see Figure 1) are specialised digital cameras designed for open-source distribution. They are very simple. In addition to the camera and a trigger mechanism, they include a small screen on the back that shows short texts that ask questions or request images, which can be scrolled using buttons mounted on either side. When a photo is taken, it is stored on an internal flash card and tagged with the text that is currently appearing. Each time a photo is tagged in this way, a small tick (√) is added to a row above the text. Flash cards can be removed to retrieve images, to change the list of texts, or to modify the operating code for the device.

TaskCams are not necessarily identical to one another. We have designed the basic hardware and software for TaskCams, and constructed multiple versions using several designs for their casings. In making them available to other researchers, we offer multiple options at each step of construction both for recreating and modifying our designs. Thus the range of TaskCams that may evolve is large and indeterminate: they are not only open-source, but open for appropriation and redesign.

At the same time, through their design as well as instructions, videos, and advice on an associated website (www.probetools.net), TaskCams serve as a new means for disseminating a design-led methodology for understanding users and their settings. They are the first in a planned series of cameras and audio devices called ProbeTools that will offer a range of possibilities for engaging with participants.

Figure 1: Examples of 3D-printed and paper-clad TaskCams. © 2018 Interaction Research Studio

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From this perspective, the devices afford a design-led style of research by making it more open, accessible, and relatively easy to pursue, rather than prescribing or enforcing it.

In this paper, we start by briefly reviewing the background of the TaskCams and describing them in more detail, focusing on their hardware, interface, and housings. We also explain our approach to opening the designs as a means of distribution and dissemination. Then, in a section written relatively independently, researchers from the Everyday Design Studio recount their experience of building, modifying, and using the devices in a Cultural Probe study. In the final section of the paper, we discuss the issues and challenges that arose from their experiences and describe how this led to changes in the final design of the TaskCams and supporting materials. Finally, we end with reflections about the potentials of a methodology disseminated via an open-source product.

BACKGROUND

There are plenty of other DIY cameras available [e.g. 6], but none to our knowledge are designed for research studies. Other researchers have developed bespoke cameras, but these are neither intended for user studies nor available as open source designs. For instance, Pierce & Paulos [35] batch-produced small cameras whose pictures could be retrieved only by breaking their concrete cases as part of an inspiring project on *counterfunctional cameras* [34]; however, they were less interested in what the pictures people took revealed than they were in the speculations such devices engender for their audiences. LaBrune & Mackay [22,23] designed a series of playful cameras for use by children; however, the insights produced by their pictures were incidental outcomes of the project rather than an intended focus. Microsoft Research's SenseCams [38] use a variety of sensors to trigger periodic image capture; designed for life-logging, they capture content automatically rather allowing their users to choose what images to capture. Finally, the CamBits [28] system allows a number of modular camera components to be reconfigured to produce a range of photographic systems; while these could be used for research studies they are not designed for that purpose nor are they open source designs. TaskCams are, to the best of our knowledge, the only DIY cameras explicitly designed for user studies. Moreover, they are distinguished from other cameras, open source or not, by their commitment to a particular approach to study.

Cultural Probes

TaskCams were inspired by a design-led approach to initial studies of people and their settings. Cultural Probes (or simply 'probes') are collections of evocative tasks designed to elicit responses that can provide insight into peoples' activities, concerns and values [3,10,11]. Originally devised in the late 1990s to inspire design work as part of the Presence project [12], they are now a well-established approach to contextual research in the HCI and design communities [4,2,37], and to some degree within the social sciences (e.g. [36,27]), and business and marketing (see e.g. [15,5,40]).

Probe collections and their component tasks vary widely (e.g. [43,4]), but usually share several features that make them engaging for participants as well as productive of useful data. Most probe tasks are *simple and easy* for participants to work with. They are *open-ended* in the sense that many approaches to responding are possible even for relatively constrained tasks. They provide for a *range of engagement*, with some inviting relatively quick responses, and others longer-term reflection. Their affective tone ranges from relatively *neutral to playful*, which simultaneously makes them enjoyable and potentially intimate. Some tasks are even *absurd or confusing* both to encourage a sense of play, and to undermine assumptions about taking part in a research project. Probes are usually designed to be used *independently* from researchers, with tasks left behind by researchers for later return. Finally, collections of probes are usually designed to convey an integrated *personality* that invites a relaxed relationship to them and the research team who produce them, conveys some of the long-term intentions for the project for which they are produced, and encourages sustained engagement with the project and team. Together, these attributes allow well-designed probes both to open a dialogue between participants and researchers, and to catch unguarded glimpses of peoples' lives and thoughts, circumventing the more crafted self-presentations that research participants might usually offer to researchers.

Electronic Probes and ProbeTools

Probe materials are often paper-based, with tasks using a wide variety of maps, postcards, diagrams, stickers or labels. However, successful probe tasks have also been based on off-the-shelf devices: e.g., disposable 35mm film cameras, repackaged with requests on their covers ("take a picture of: a social gathering / the view out your window / the spiritual centre of your home / something red"); a simple digital recorder repackaged as a device giving give people ten seconds to recount a 'vivid dream' upon awaking; a higher-spec digital recorder used to capture night-time sounds by caravanners. Such tasks can supplement those calling for writing, drawing or annotation by allowing capture of visual and audio details of participants and their environments, either spontaneously or after some planning.

There are several reasons to go beyond the disposable cameras and simple video and audio recorders used in the past. First, such devices offer a generic set of functionalities that limit their application as probes. Moreover, the widespread use of mobile computing in the form of digital cameras, smart phones and tablet computers has reduced their availability. The growing ubiquity of mobile computing might seem to compensate for this by allowing the design of probes based upon new devices, and indeed other researchers (e.g. [14,16]) have based probe studies on smart phones and similar devices. There are several drawbacks with using commercial devices for probes, however. Perhaps most

Figure 2: Disposable camera relabelled with requests for images – the model for the TaskCams. © 2018 Interaction Research Studio

importantly, probe returns are most revealing when they are *spontaneous and unedited*, whereas most common digital devices allow review, editing and deletion. Probe tasks also benefit from *playful constraints*, whereas commercial devices are typically feature-led. Finally, probe materials are usually presented as collections of *separate, stand-alone* items offering their own affordances, whereas commercial devices typically present a relatively homogenous collection of 'apps' that compete with one another and must be explicitly activated. In general, it appears difficult to use smart phones or tablets to develop probes that fully realise the simplicity, playfulness and personality characterising the best examples of the approach.

The ProbeTools project thus builds on the increasing availability of low-cost rapid prototyping tools, to investigate possibilities for digital devices specifically developed for probe studies.

Disposable Cameras and the TaskCam

Probably the most frequently reiterated electronic probes are repackaged disposable cameras (see Figure 2). They have proven effective across a wide variety of contexts at eliciting surprising and richly informative images of participants and their settings. With the advent of smartphones, however, finding disposable cameras, and particularly the services to develop them, has become more difficult. Increasingly, disposable cameras have begun to seem anachronistic.

TaskCams are essentially designed to recreate the features of these repackaged disposable cameras. In addition to features they offer, such as the ability to list requests for pictures, this shaped our thinking about the features that they don't offer (cf. [33]). Most notably, and like disposable film cameras, TaskCams do not have a screen for previewing or reviewing images, nor do they have any facility for editing or deleting pictures. We believe this deters participants from creating overly staged images or from deleting and retaking images when dissatisfied. In addition, and like many disposable cameras, TaskCams have no or only very approximate viewfinders, which increases the chance that unexpected or unintended elements will be captured. Finally, the TaskCams have several features that disposable cameras do not: most notably the capability to take tens or hundreds of photos (most disposable film cameras can only take about 40), allowing multiple pictures to be taken in response to a given prompt and for unprompted pictures to returned as well.

TaskCams are the simplest of the ProbeTools currently under development. Others that we intend to circulate will take advantage of the opportunities offered by bespoke digital photography, and in particular image manipulation and processing. For the TaskCams, the first in the series, we were concerned with a simple, affordable, and broadly useful design expected to be the workhorse of the collection. In the following sections, we discuss its design and implementation in more detail, and then other elements of the system to support open-source distribution.

TASKCAM DESIGN

In this section, we discuss the TaskCams' hardware and interface, and then the casings we have developed to house the devices' electronics.

Hardware

Most TaskCams are built using an Arduino Uno microprocessing platform [1] linked to a Linksprite JPEG Camera [25] via an Arduino 'shield', designed and produced by the Interaction Research Studio, that plugs directly into the Arduino's existing IO pin headers (Figure 3). The shield incorporates the text display, a Micro SD card reader, and the camera trigger, and allows the camera module to be plugged directly into it. The Arduino can interface with the shield in two ways: it can tell the camera module to capture a photo, and request the questions which are stored in the SD card so that they can be displayed on the screen. In addition, the Arduino is used as a way for programmers to access the shield. The device is powered by two AA batteries in a separate holder wired to the shield.

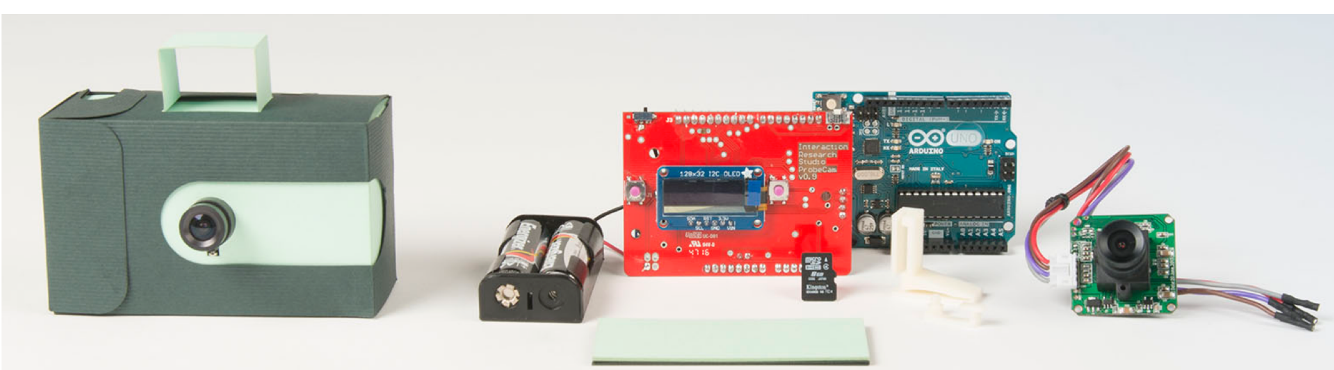

Figure 3. Paper TaskCam with hardware components. From left to right: battery holder, custom shield with SD card in front, Arduino Uno, and Linksprite JPEG Camera. © 2018 Interaction Research Studio

The previous paragraph begins with the word 'most' because there are many possibilities for reconfiguring the hardware of the camera. We chose the Arduino Uno for its size and low price, but many other Arduino boards could be used instead to take advantage of other built-in sensors or networking capability. Similarly, we currently use the Linksprite JPEG Camera, but any camera with a serial connection can be used with the hardware, for instance to develop more specialised cameras. Although the display would be more difficult to replace, this too could be achieved with the current shield though new wiring and programming might be required.

The shield itself will be available in a ready-to-use form via our website, potentially by way of a third-party hardware distributor. Plans for the PCB and a list of components to be mounted upon it will also be made available for downloading by makers able to build (and potentially modify) their own. We had originally planned for this to be the only way of obtaining the shield, but although we designed and produced versions of the shield entirely in-house, the demands of producing and populating them convinced us to batch produce fully populated versions to make the process easier for others.

Currently the TaskCam hardware (including the Arduino Uno) costs about £35, or $45, which we believe is a reasonable price for a reusable tool for research.

Interface

The basic operation of the TaskCam is very simple. An on-off button controls power to the device. Two buttons control the upwards and downwards scroll of text on the small screen. A side-pull switch triggers image capture. When an image is taken, a tick is added above the text being displayed (on the assumption that the image refers to that text). The SD card can be removed by researchers, with casings usually designed to dissuade users from doing this themselves.

For researchers, the easiest way to interface with the TaskCams is via the SD card. This allows questions to be entered via a simple text file for display onscreen (see website, below). Programmers may also use the Arduino's USB port to modify the TaskCam's user interface.

Casing Designs

The external casings for the TaskCams are crucial both for functional and aesthetic reasons. They house and protect the underlying hardware, and provide a means to hold and operate the device. Equally, if not more importantly, they determine the devices' identity to researchers and participants. Moreover, the design of casings constrains and is constrained by hardware choices, and is influenced by the tools and techniques required for their making.

We experimented with a large number of possible designs before settling on the two we are releasing as finished designs[1].

3D TaskCam

One of the two casings we are distributing is designed to be produced on 3D printers (Figure 1). Simple and robust in use, one of its most significant features is that it can be printed with no support material, allowing it to be made on a very wide range of printers including old or very inexpensive ones.

The case is produced in four parts that slot together and are held by two screws. The camera protrudes through an aperture in the front with the board mounted by two screws to the inside surface. Similarly, the screen is shown through a rectangular aperture in the back of the device. A separate printed on/off switch is glued to the smaller switch on the board and protrudes through a slot on the top of the device. Other buttons (trigger and screen controls) are accessed via printed cutouts on the top and back of the casing that flex enough to activate the switches on the shield.

The overall form of this case is rectilinear and includes relatively large planes to which stickers can be attached, whether to add instructions or to 'brand' the devices for particular projects. Front and back viewfinders give an approximation of the camera's field of view.

Plans for the 3D casings are made available to download in all popular 3D formats (currently .STL and .STP) via a link on the website which leads to the GitHub repository [13]. Fully editable AutoDesk Fusion 360 designs are also available via the website.

Paper TaskCam

The second casing is made from paper or card cut from two A4 sheets (Figure 3). The intention was to provide a means to house the devices that did not depend on specialist equipment: the design is distributed in the form of downloadable templates which can be printed directly on the paper. Thus the case can be cut out by hand, though laser cutting is likely to give more precise results.

The design involves an inner and outer case, with the two layers providing additional stiffness and also allowing different colours and textures of papers to be combined. Hardware is inserted into the inner case, and the outer case slides over it like a sleeve. Most joins are secured with glue or double-sided tape, but the last flaps of the outer case tuck in allowing it to be opened easily by researchers. A folded paper viewfinder slots into the top of the device.

Using printed card or paper for this case makes customisation easy, whether through choice of stock or via printing, painting, or writing. The result is not as robust as the 3D

[1] We will also make all of the other designs we tried available on the ProbeTool website for those who might want to adopt or modify them.

TaskCam, but is approachable, easy to customise, and (in our opinion) quite elegant.

Designing for Open-sourcing

The design of the TaskCams has been pursued with the intention of making them successful as open-source products and open to both surface and deep customisation. A number of considerations were involved in this. For instance, the devices are designed to be simple both in terms of the materials required and the effort needed to construct them, and also relatively inexpensive to produce. They are also designed around the likely availability of parts, and the possibility of replacing parts should existing ones be discontinued. Distribution of the design is greatly aided by using GitHub, a software repository of interest in its own right [42,26]).

Extra-Open Open-Sourcing

Many open-source projects provide the resources to replicate the processes and outcomes of their designers, but are inflexible to changes in tools, materials or skillsets. Our purpose in offering a number of options at each stage of the making process is to provide multiple routes to achieving working TaskCams, as well to ensure that the design is open to modification. The idea is to go beyond a set of step-by-step instructions for assembling specific parts to instructions that convey the purpose of each step and that allow multiple ways to achieve it, or to choose alternative paths. In this way, we open open-sourcing to a wider range of possibilities for creating devices identical, similar, or radically different to the TaskCams we have made.

www.probetools.net

Key to our strategy for open-sourcing both the TaskCams and the methodological they embody is the website we have constructed. Informed by other examples of open-source projects (e.g. [30,31]), www.probetools.net provides a richly-illustrated access point to the project that integrates several functions, acting as an introduction to the project and specific devices, offering advice for designing Probe studies, and providing a repository for visitors to upload information about their own use of ProbeTools.

Most importantly, the website includes a dedicated page for each ProbeTool that describes the device and its use and provides instructions and resources for its construction (Figure 4). Inspired in part by a popular cooking site [7], each page provides a 'recipe' (c.f. [8]) that is headed by a photograph and a short description of the device, followed by a list of components and useful tools and a step-by-step illustrated guide to its construction (Figure 5). In addition to links to specifications and templates, widgets are provided on the webpage itself to, e.g., construct a text file of questions for uploading to the TaskCams.

Dedicating a single scrolling page to each device keeps the website simple and modular and allows expansion as new ProbeTools are added. At the time of writing, both the 3D and Paper TaskCam have dedicated pages on the site, with a holding page for devices currently being developed. We anticipate this will be updated with new designs by Spring 2018 if not before.

Beta-Testing TaskCams

We presented prototype TaskCams at CHI workshops over two consecutive years [19,20]. At the first, in 2016, we brought six prototype 3D TaskCams and lent them to colleagues to try over the course of the conference. This revealed issues (e.g. battery life) which we addressed in redesigns. Some participants also expressed interest in trying the TaskCams in their own studies. Thus, for the 2017 workshop we brought a set of TaskCams (two kits plus one assembled sample for each of the 3D and Paper TaskCams, for a total of six devices) to deliver to members of the Everyday Design Studio to try in their work.

The following section is a report from the Everyday Design Studio of how they incorporated TaskCams in their study. While the authors from the Interaction Research Studio have seen and discussed this report, we have not tried to alter it apart from suggesting that it focus more on the TaskCams than their study for the purpose of this paper. Thus, this section can be read both as 'data' to help assessing TaskCams, and as completing the discussion so far by following TaskCams through to their use in the field.

There are several things worth noting in reading the following discussion. First, our focus is on how the Everyday Design Studio was able to adopt and adapt TaskCams based on the resources we gave them, rather than reporting on the results of their study. Second, the prototypes

Figure 5. Partial screenshot of instructions for making Paper TaskCam. © 2018 Interaction Research Studio

were not finished TaskCams: we were aware of several issues of build quality, and also knew that some of the specifications and templates were not flexible enough to readily support modifications. Finally, we note that members of the Studios already enjoyed a positive professional relationship that may have eased difficulties that might appear when distributing the devices to other researchers and practitioners. Despite these limits, their experiences were useful in considering whether the resources we provided would allow TaskCams to be realised for use in a study.

TASKCAM DEPLOYMENT: VANCOUVER, CANADA

The invitation to test the TaskCam platform coincided with a new project we [the Everyday Design Studio] were beginning in our studio that explores the values and practices of people that actively adopt living situations that are alternative to normative domestic dwellings. The HCI community has long researched 'the home' and 'domestic life', and applied diverse methods to these investigations [9,21]. However, with a few notable exceptions (e.g., [18,24,,29,39,32,44]), conceptualizations of *what the home is*, *where it resides*, and *how it is made and by whom* have arguably remained somewhat narrow in the HCI community.

For our project, we wanted to recruit a diverse pool of people to gain insights into potential overlaps and differences in their practices and dwellings. In adopting a design perspective, our goal is to capture rich examples of our specific participants' lives, values, practices, and ways of enacting domesticity on their own terms. We aim to use these resources to shape our next design moves; we were less concerned with collecting data that would be generalizable or representative of an entire population.

For our initial deployments of the TaskCams, we recruited a (i) a tiny house dweller living on a nearby island, (ii) a micro-loft dweller living in downtown Vancouver, (iii) a self-described minimalist single parent living a small downtown condo with five children, (iv) a nomadic pet/house sitter perpetually moving from one dwelling to another, and (v) a vehicle dweller permanently living in a retrofitted van. The tiny house and micro-loft dwellers also adopted zero waste lifestyles, which strongly emphasizes the reuse of all materials and products to prevent sending any trash to landfills or incinerators. We have since recruited additional boat, vehicle, cooperative, and collective house dwellers for future cultural probe deployments as a part of our ongoing project.

Cultural Probes: Constraints, Motivations, and Fit

In the early stages of conceptualizing our project, we grappled with determining what would be the best approach to enable us to gain rich insights into our participants' lives. Similar to several issues mentioned in earlier sections of this paper, our own practice of using cultural probes in our research and teaching had dropped off due to a lack of a viable options for integrating photographic capabilities—disposable cameras were increasingly difficult to find and had limited exposures, and phones/digital cameras disrupted the cohesiveness and uniquely craft qualities that are essential to cultural probes.

We initially envisioned a hybrid approach that combined in-person interviews with photographic inventories of the things and places characterizing each participant's respective dwelling. However, this observational approach also raised tensions. Our participants were living in circumstances that were somewhat hard to access and/or in a legal grey area (e.g., a van parked on a city street). At the same time, the participants we recruited were eager to share non-formal aspects of their created living situation. It was clear that our participants exhibited resourceful, creative, and critical perspectives on their things and dwellings, making them ideal candidates for a cultural probes approach. As the possibility of using the TaskCam platform emerged, we reoriented our efforts toward to crafting and designing cultural probe kits. In the sections that follow, we detail our process of using and working with the TaskCams

Working With the Taskcams and Making them Work

We received components for six TaskCams (three paper and three 3D printed enclosures). We did not encounter major difficulties in initially assembling the TaskCams. It is worth noting that our design team has a reasonable of familiarity with using and tinkering with 3D printers and laser cutters. Additionally, the nature of our probes project itself, and the ethos of our studio more generally, emphasizes a Do-It-Yourself (DIY) attitude and sensibility. Whether wittingly or not, we were likely primed to put in time to figure out the TaskCams on our own terms. We did initially explore the online tutorials to guide our delicate placement of the TaskCam electronics into the enclosures (particularly for the 3D printed version). We printed the enclosures in ABS on a high-end Fortus 3D printer and in PLA on an Ultimaker 2+ 3D printer; both fit relatively easily together with minimal adjustments. After calibrating our laser cutter for card stock paper, we were able to fabricate and assemble the paper enclosures.

We created mood boards—populated with images, press articles, and our own photos and sketches—for each of the different groups we aimed to engage: zero wasters, minimalists, tiny house, collective house, boat, and vehicle dwellers. These explorations revealed subtle overlaps and differences in motivations among the groups we were interested in. This helped us see how we could create cultural probes that could be individualized for each participant, while cohesively scaling across all of them.

We then began populating the TaskCams with questions probing into key issues, ideas, and topics we wanted to invite our participants to respond to through photos. This involved an iterative process of testing different versions of TaskCam questions in our own everyday lives and reflecting on their relative success (i.e., maintaining an open-ended, interpretive quality while still being somewhat intelligible). It became clear we needed to craft a set of questions that struck a balance between eliciting responses that were specific to each participant's life as well as broader feelings about the idea of home—the things, practices, and places that make it—that could span across all participants. We also included a set of ambiguous terms and phrases (e.g., 'connection', 'disconnection', 'chaos', 'waste', etc.) for participants to respond to.

This process helped us understand how the TaskCam could work as a central element in our probe kits. It also made clear that we needed to expand with a diversity of cultural probe activities in terms of material, form, and temporal pacing that could, in subtle ways, connect to underlying themes in the TaskCam questions. Through iteratively tuning the initial sets of questions, the TaskCam worked as a resource to contemplate and speculate on our participants' lives in the context of our own design practices and motivations. Importantly, these early TaskCam explorations did not exist in isolation. Our participants all reflected a commitment to resourceful ways of living and, albeit to differing degrees, re-use and sustainability; on a basic level, our cultural probes kits needed to reflect this. To support this goal and empathize with our participants' commitments, we began exploring materials that could integrate these values into our probes (e.g. making our own paper and using discarded textiles). These practices catalyzed our next moves in designing a set of probe tasks that, in turn, shaped our use of the TaskCams themselves.

Moving from TaskCams to Cultural Probes

In our final cultural probe kit, the TaskCam and other probe tasks were organized in a canvas drawstring bag with several pockets and compartments that we created from second hand sheets (Figure 6). Stemming initially from the values and practices of our zero waste participants, as well as a desire to understand different approaches to ownership, the probe bags have an explicit focus on the lifecycle of the materials we used. The bags and tasks were crafted from reused, reusable, or recyclable materials and the bags themselves will be passed on to our next rounds of participants.

Because the focus of this paper is on the TaskCams and our appropriation of them, here we only very briefly describe the other Probe activities to give a flavour of the entire kit:

Personalized Invitation For each participant, we created a personalized invitation from homemade paper and cotton thread that exhibited her or his name laser etched on the front cover and included a brief statement about our design studio, aims of our project, and each probe task.

Traveling Rock Participants were invited to write the date, location and/or short messages on tags attached to a small rock (*zwerfkei* in Dutch). The zwerfkei travels with the bag, calling attention to its ongoing story and shared ownership.

Stitching together the fabric of home life Two sets of six subtly conflicting words, representing values of home life the participant may or may not identify with or experience, were embroidered on one of two triangularly shaped pieces of fabric that are folded together (the other was embroidered with evocative visuals). Participants were tasked with sewing a pathway through the terms that they felt best represented qualities of their home life, including and leaving out words. We see this task and the related, more ambiguous prompts on the TaskCam as mutually informing.

Us and Them Three metal tins are stamped with 'meme-like' statements: *how the mainstream thinks I live*; *how the cashier thinks I live*; and *how I actually live*. Participants were invited them to take their time and be creative with what to put in them.

Soundscapes, stories & secrets We included an audio recorder in the bag with several prompts inviting our participants to capture soundscapes and stories of their everyday life with us. The audio recorder was also used in combination with other probe tasks, such as Imagining In and Out, and the Waste Capsule to offer an optional modality to capture additional oral reflections if desired.

Imagining In and Out We invited participants to use two rolls of different colored tape to outline things, spaces or functionalities that they wish they had, as well as those that they wish were no longer there, and to take a picture of the result with the TaskCam. We had to omit this activity from our zero waste participants' kits due to its disposable nature

Figure 6. The cultural probes bag and a view of the probe activity contents crafted for our minimalist participant.
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and the tape being comprised of plastic material.

Waste Capsule

This activity replaced Imagining In and Out for our zero waste participants. The waste capsule is a glass jar we asked our zero waste participants to fill with the waste they collected over the period of having the probe bags with them. The participants were asked to annotate its contents at the end, using the audio recorder.

Parting Remarks

This last exercise is a booklet made from our homemade paper, with prompts etched into it that covered overarching themes across the TaskCam and other probe activities.

Crafting Personalized TaskCams for Deployment

For each of our participants, we adjusted, left out and redesigned (parts of) tasks in the probe bag to fit their values. As noted, our zero waste participants introduced special concerns. These participants' sensitivity toward wasteful materials—especially plastics—also required us to create unique enclosures for their TaskCams. While the robustness of the ABS plastic enclosure was advantageous, the disposable nature of this material would clash with their values. We first experimented with 3D printing PLA enclosures because it is a biodegradable material derived from cornstarch or sugarcane. Yet, the aesthetics of the PLA still unequivocally expressed "plastic." This prompted us to explore different materials for the TaskCams, including a home-made paper enclosure (Figure 7) as well as one from recycled wool blankets (Figure 8). In our explorations with wool, we used a fabric stiffener to create a strong yet soft camera enclosure (Figure 9). However, unlike paper, wool shrinks and changes structure slightly while the applied stiffener is drying, a process that is hard to predict especially when working with knits of products that once were (e.g., sweaters and blankets). This required several iterations and multiple sweaters to get a grasp on the shrinkage and adjust the laser cutter schematic TaskCam file accordingly.

We experienced a similar process of intimately working with the TaskCams with our home-made paper enclosure. Our paper was created out of mixed scrap fibers and offered less support for the electronics than the 3D printed version, or the original card stock paper TaskCam. This highlighted an issue

Figure 7. To support the sustainable and resourceful goals of our participants, we began making our own paper recycled from paper scraps produced in our studio. The paper was used for the Personalized Invitation, the Parting Remarks, as well as for the enclosure of one of the TaskCams. © 2018 Everyday Design Studio

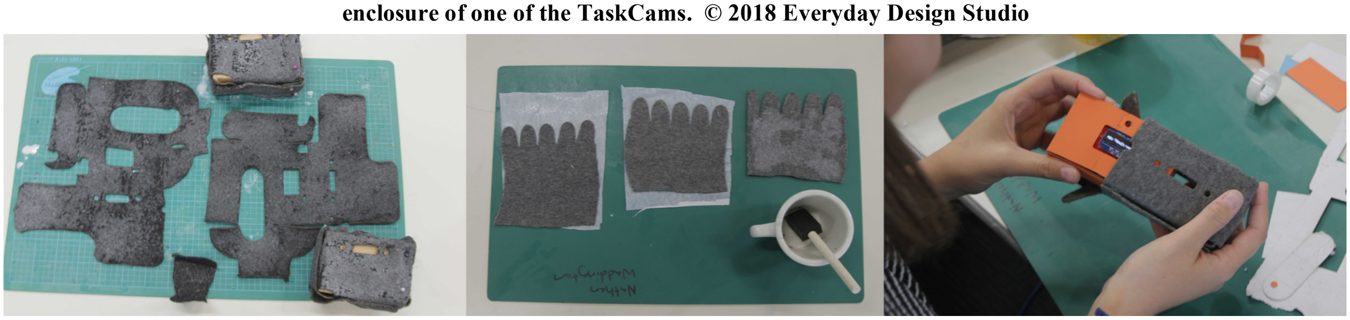

Figure 8. Our experiments with the soft enclosure included iteratively resizing the original lasercut file, stiffening the fabric using interfacing and applying fabric stiffener on the flat (pre-lasercut) and assembled (post-lasercut) enclosure. © 2018 Everyday Design Studio

Figure 9. Variations on TaskCams: the wool and home-made paper enclosures and the aerosol painted 3D prints. © 2018 Everyday Design Studio

with the TaskCams on/off switch and the 3D printed lever. This lever, as well as the switch itself ended up breaking during our explorations. Considering we are an early adopter of the TaskCam, the website-based tutorials did not cater to the level of detail needed to help us troubleshoot these issues. This required us to directly request a set of slightly different design variations of the fragile lever in the form of a .STL file (for 3D printing) from our collaborators in the Interaction Research Studio to find the right 'fit.' We then iterated through several rounds of 3D printing the lever, in which several more broke, and others were filed down by hand until we reach a precise fit for each TaskCam board. This process produced a dilemma: in order to test if our homemade paper or wool enclosures would function, we had to actually fit them to the TaskCams and use them over time. This produced excess wear on the TaskCam boards, causing several of the surface mounted power switches to break off. This introduced further issues. We had difficulties finding power switches to repair the TaskCams, which required us to consult an expert in imported electronics that eventually scavenged specialized switches that would also work on our boards. We then had to carefully apply considerably more difficult soldering techniques to repair each board and affix the broken SMD power switch components.

While we avoided the 3D printed TaskCams for our zero waste participants, for others, that are more nomadic or live a minimal lifestyle with a sleek domestic aesthetic, the ABS enclosures were well suited. We printed the enclosures in ivory and modified their colour with aerosol paint (Figure 9). The acetone in the ABS material easily bonded to the paint and produced a streamlined aesthetic without requiring sanding or using a paint primer. This enabled us to avoid purchasing costly canisters of different coloured ABS filament and cheaply produce small batches of TaskCams that were hardy, robust, and aesthetically fit with other probe activities that were lightly accented with the same colour.

Overall, the TaskCam was flexible to work with and, as we explored our material options, we found ourselves making use of, adapting and expending the open-source resources that we had at hand much more than when we were simply putting the TaskCams together. Given the material focus of our probe bags, we explored and set out to learn new skills related to these specific materials, such as sewing, embroidering, metal stamping, and papermaking. Unsurprisingly, this came with a learning curve, and involved some trial and error. We see these efforts as a form of reciprocity, recognizing the values of our participants and being thankful to them for sharing their thoughts, practices, and lives with us. This approach also provides a perspective on our hiccups with working with the TaskCams where they influenced and were influenced by other probe activities. These frictions with the TaskCams ultimately seemed little different from the other activities that required us to get to know the material, speculate on how it would shape each participant's experience, iteratively adjust it, and learn new skills to attuning the design so it was 'right'.

DISCUSSION

Difficulties the Vancouver team encountered in constructing and modifying the TaskCams for their study have been useful in thinking about how to redesign the devices, and raise issues for the prospects of opening open-source designs more generally. For instance, as they worked to house the TaskCam components in novel materials, they had to modify the templates provided for the Paper TaskCams over several iterations. When they sought to fit their custom-designed casings, they had problems with the power switches, and 3D printed levers that attached to them, breaking off from the shield. Moreover, they found that sourcing new power switches for the boards was difficult, and it was also expensive to order overseas parts into Canada because of import duty. In the end, they managed to produce a set of TaskCams that met their requirements, but not without some difficulty.

Those of us in the Interaction Research Studio had expected some of these problems as we knew the design was not finalised. For instance, in the versions the Everyday Design Studio were given, the power switch was a last-minute hack to replace one that didn't allow the device to be turned off manually (instead assuming a sleep mode we couldn't implement). Unfortunately, the replacement part didn't quite fit and we knew it was prone to break off. Nonetheless, the Everyday Design Studio's experience drew attention to the inherent weakness of slide-mounted slide switches. These are problematic in commercial designs, and in the bespoke casings for TaskCam much more likely to suffer from alignment issues and premature wear from multiple insertions into the case. We have replaced all side-mounted switches and moved all the switchgear to the rear panel of the camera. Through modifications such as this, and informed by the Everyday Design Studio's experiences, we have refined the design to produce what we believe is the definitive TaskCam hardware, and expect that this will minimise fragility.

The New and Improved TaskCams

For the final TaskCam design, all the components (Arduino, shield, camera and battery pack) are mounted on a single PCB available from our website. This can be used with no assembly as a fully-functioning barebones TaskCam, or housed in a 3D printed or paper (or fabric, or…) case. The PCB is perforated and predrilled, moreover, allowing the components to be snapped apart and reconfigured in a variety of ways, suitable for housings including, but not limited to, 3D and Paper TaskCams. Many configurations (including one for a screenless camera about the size of a box of matches) are possible without soldering simply by plugging the separated boards together, and many others with a limited amount of soldering. We believe this design will be robust, and extremely easy to use and modify.

Perhaps one of the differences between open-source code and open-designs (Instructables [17], Thingiverse [41] etc) is that open-designs are often distributed as STL

(STereoLithography) files that describe only the surface geometry of a three-dimensional object, making complex assemblies such as TaskCam difficult to edit (since they lack the source files to generate the STL ones). In contrast, we will be releasing the all the original 3D models for all our designs, allowing users absolute control over geometry and in the case of parametric modelling used in software packages such as Solidworks and Fusion 360, automated generation of 3D models based on users entering basic dimensional data. For instance, the Everyday Design Studio modified the 2D templates for the Paper TaskCam to accommodate the thicker fabric based material that used in their study. Having realised that this may be a common requirement among users, the Interaction Research Studio will develop specific online instructions to automatically generate 2D bespoke templates based on a custom material thickness, while also making available a variety of templates for most stock thicknesses of paper and card.

Nothing's Perfect

We expect the finalised TaskCam hardware, casings and interface software to be robust and accessible enough to be built easily and to withstand the pressures of modification. In addition, because source files for all our designs will be available online, TaskCam adopters will be able, in principle, to replace or modify any of their components.

Nonetheless, the experiences of the Vancouver design group suggest that it is impossible to predict all potential problems or to foresee what resources will be needed to work around them. Moreover, as one of the Vancouver authors pointed out in discussing this paper, trying to design out all conceivable problems might well end in devices that are too finished to be open-ended in the way we intend. From this perspective, the hack-ability (and the troubles that come with it) are as much a consequence as a catalyst for the creativity of whoever is using the TaskCam.

A Community of Practice?

Given the likelihood that open-ended, open-sourced designs will always be prone to difficulties when people actually start to modify them, the ability for TaskCam developers to share their workarounds and modifications via the ProbeTools website will be crucial. We currently cater for this by offering links to GitHub for each of the designs, allowing new specifications and remarks to be uploaded, and are also considering offering a facility for people to enter their questions and suggestions directly on the site.

Beyond serving as a space for discussing questions and solutions, we hope that a community space will grow into a forum for sharing new ideas and best practice surrounding the TaskCams. For instance, beyond the Interaction Research Studio explaining how to print more robust components (for instance), the Vancouver design team might share their modified templates for fabric and wool TaskCams, their tips for how to produce homemade paper, or their reflections on the questions and tasks that worked best in their studies. Clearly, the more groups start using and sharing ideas about TaskCams, the greater the benefits.

Open-Sourcing a Design Methodology

Already, the experiences recounted by the Everyday Design Studio are encouraging. As they describe, they were able to use the kits, instructions and templates to develop TaskCams for their probe study, to customise the devices for the particular user groups they engaged, and to reuse the TaskCams with multiple participants.

Moreover, their account supports the idea that making TaskCams available as an open-source product serves as a novel strategy for disseminating the methodological approach behind Cultural Probes. As they write, the availability of the TaskCam kits rekindled their interest in an approach that had fallen out of favour, and was influential in shifting their plans away from using interviews and photographic documentation. In addition, they describe how the process of refining questions to use with the devices influenced their probe designs more generally. In this regard, TaskCams exerted a kind of agency in their project, one they felt beneficial, that may be replicated in others.

The contributions of this paper, then, are three-fold. First, we describe our approach to designing an open-source and open device that affords and disseminates a particular approach to design-led user research. Second, we trace the development of TaskCams from the Interaction Research Studio through to their successful construction, customisation and use in the Everyday Design Studio, highlighting some of the issues they encountered in making and customising this open-source product. Finally, and perhaps most importantly, we introduce TaskCams themselves, the first of a planned series of ProbeTools, and invite members of the CHI community to adopt and adapt them for their own uses.

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