Reflective Design

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ABSTRACT

As computing moves into every aspect of our daily lives, the process, values and assumptions that underlie our technical practices may unwittingly be propagated throughout our culture. Drawing on existing critical approaches to computing, we argue that reflection on unconscious values embedded in computing and the practices that it supports can and should be a core principle of technology design. Building on a growing body of work in critical computing, we describe reflective design, a practice which combines analysis of the ways in which technologies reflect and perpetuate unconscious cultural assumptions, with design, building, and evaluation of new computing devices that reflect alternative possibilities. We illustrate this approach through two design case studies.

Keywords

Reflective design, critical technical practice, participatory design, critical design, value-sensitive design, ludic design, reflection-in-practice, critical theory

INTRODUCTION

Information Technology (IT) is everywhere, shaping the way we experience our lives, the world, and each other. For many of us, the texture of our work lives has long since been steeped in a symbiotic relationship with the technologies that shape and sometimes define our work practices. In the last 15 years, we are seeing similar shifts in other areas of everyday life: e.g. passersby hook into their iPods and chat on their mobile phones, coffee shop patrons commandeer couches while transfixed with their laptops, business travelers squat on airport floors tethered to power for the gadgets that organize their lives.

As technology designers it can be both exhilarating and unnerving to see how the design decisions we make, consciously or unconsciously, shape the micro-texture of people's everyday experiences. As people adapt to the opportunities and constraints provided by our technologies, their everyday practices, feelings, even their identities and sense of self may shift, often ways unanticipated ways. As designers, we are left to wonder: what values, attitudes, and ways of looking at the world are we unconsciously building into our technology? To what effect? How can we find and address blind spots in our approaches in order to make design decisions that may lead to improved quality of life?

Indeed, over the last 30 years, recognition of critical blind spots in human-computer interaction (HCI) has opened new design spaces and led to improved technologies. For example, researchers have argued that HCI's perspective on automating work practices was blind to IT's role in the politics of the workplace and to the complex organization of apparently routine activity. Developing an awareness of these factors led to new strategies for democratic design of IT and for integrating ethnographic insights into new technology design [41]. In another example, researchers argue that HCI's focus on cognition has inadvertently led to a discounting of emotion in interaction, and are developing methods for bringing a sensitivity to user emotions into interface design [35]. In the most recent example, researchers are raising questions about the centrality of work as the object of HCI's study, arguing that HCI methods developed for workplaces are risking making all of life like work [4].

In each of these cases, researchers identified values, practices, and experiences that were unconsciously, but systematically, left out of HCI. The ways of viewing human activity that they criticize were so naturalized, i.e. so much a part of our HCI worldview, that it was often hard, at first, both to understand that something was missing and to imagine that HCI could be meaningfully pursued in another way. These critiques made it possible to question why particular aspects of human life were left out of design, to discuss whether or not they should be, and to begin to imagine new HCI methods that could more adequately address important parts of human experience.

In this paper, we build on the critical tradition within HCI to develop a systematic approach to folding critical reflection into the practice of technology design. We start by defining critical reflection, its importance, and its influences in HCI. **Critical reflection identifies unconscious assumptions in HCI that may result in negative impacts on our quality of life**. Critical reflection *itself* can and should be a core principle of technology design for identifying blind spots and **opening new design spaces**. We argue that ongoing **reflection by both users and designers** is a crucial element of a socially responsible technology design practice. We demonstrate how reflective design can work through two case studies. We end with a discussion drawing from our theoretical grounding and case studies to enumerate principles, strategies and challenges for this practice in HCI.

DEFINING REFLECTIVE DESIGN

What is reflection? Why reflect?

Our perspective on reflection is grounded in critical theory, a Western tradition of critical reflection embodied in various intellectual strands including Marxism, feminism, racial and ethnic studies, media studies and psychoanalysis.

(The potential of Eastern reflective traditions such as Buddhism for HCI is beyond the scope of this work. [42] suggests ideas in this direction.) Critical theory's roots lie in the philosophy of the Enlightenment, which argued that the world should be understood, not by accepting unthinkingly the teachings of authorities such as the Church, but through individual reasoning. In doing so, they laid the foundation not only for the scientific tradition but also for criticism of formerly sacrosanct institutions such as religion and the state.

Later thinkers began to realize that individual reasoning is not always enough to identify and find alternatives to common cultural, social, or political assumptions. This is because our very way of reasoning about the world is based on unconsciously held assumptions and perspectives that strongly condition what we see happening around us before we even begin to reason about it. Critical theory argues that our everyday values, practices, perspectives, and sense of agency and self are strongly shaped by forces and agendas of which we are normally unaware, such as the politics of race, gender, and economics. Critical reflection provides a means to gain some awareness of such forces as a first step toward possible change.

In the previously illustrated HCI examples, we can see similar issues arise. HCI as an intellectual field shapes what we as practitioners believe is technically feasible and desirable, while sometimes blinding us to other possibilities. Critical reflection on the limitations of the field's methods and metaphors can help us to see the world in a new way, identifying and weighing new technical possibilities.

But given critical theory's emphasis on critical reflection as an essential tool to allow people to make conscious value choices in their attitudes and practices, the value of reflection for HCI goes beyond simply opening new options for designers. It can support new awareness and freedom for *users* as well. We believe that, for those concerned about the social implications of the technologies we build **reflection itself should be a core technology design outcome for HCI**. That is to say, technology design practices should support both designers and users in ongoing critical reflection about technology and its relationship to human life.

We define **'reflection'** as referring to ***critical* reflection, or bringing unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice**. **This critical reflection is crucial to both individual freedom and our quality of life in society as a whole**, since without it, we unthinkingly adopt attitudes, practices, values, and identities we might not consciously espouse. Additionally, we recognize that **reflection is not a purely cognitive activity, but is folded into all our ways of seeing and experiencing the world.** Unconsciously held assumptions are not things we rationally know; they are part of our very identity and the way we experience the world. At the same time, critical reflection does not just provide new 'facts;' it opens an opportunity to experience the world and oneself in a fundamentally different way. Even in mundane activities such as shaving one's legs, shopping for meat products, or navigating busy urban streets, critical awareness of feminism, factory farming, or racial issues alters our perception and interpretation of what is going on around us and the implications of our actions.

To make reflection, in this sense, a central part of our technology design practices raises several questions. How can designers become more aware of the 'blind spots' in the structure of HCI as a field? How can we help users become more reflective about the role of technology in their lives? How can users and designers move reflection beyond a superficial intellectual awareness to new lived experiences? How can reflection become a not only desirable but also useful part of technology design?

Foundations of Reflective Design

In developing a practice of reflective design, we have been strongly influenced by existing critical approaches in HCI. Here, we describe how we draw on these trends to develop an approach to HCI to support ongoing critical reflection.

Participatory Design

Our approach is made possible, first of all, by the foundation laid by participatory design (PD) [e.g. 5,23,33,37]. PD advocates changing not just systems, but practices of system-design and system-building as well, in order to more fully support democratic values at all stages of the design process. For example, members of the joint Swedish/Danish UTOPIA project worked closely with the Nordic Graphic Workers' Union to develop the TIPS system, a computer-based tool to aid skilled workers in page layout and image processing for newspapers. The UTOPIA researchers used several now-iconic participatory design strategies, including low-fidelity mockups and work organization games to gain a deep, contextual understanding of users' potential interactions with new technologies so as to leverage their existing skills and experiences [13].

From participatory design, we draw several core principles, most notably the reflexive recognition of the politics of design practice and a desire to speak to the needs of multiple constituencies in the design process. Participatory design has, of course, been taken up more broadly in HCI as user-centered design, which also informs our approach, although, as Asaro points out [2], user-centered design does not necessarily follow the political strategies of 'classic' PD.

Compared to PD, however, reflective design must make a different commitment about the practices which we as designers choose to support. PD strategies tend to be used to support existing practices identified collaboratively by users and designers as a design-worthy project. While values clashes between designers and different users can be

elucidated in this collaboration, the values which users and designers share do not necessarily go examined. For reflective design to function as a design practice that opens new cultural possibilities, however, we need to question values which we may unconsciously hold in common. In addition, designers may need to introduce values issues which initially do not interest users or make them uncomfortable. To do this, we draw on several other critically-informed technology design practices.

Value-Sensitive Design

Our interest in and focus on values in the design process is inspired in part by Batya Friedman's [16] value-sensitive design method (VSD). VSD provides techniques to elucidate and answer values questions during the course of a system's design. To do so, VSD employs three methods: conceptual investigations drawing on moral philosophy, which identify stakeholders, fundamental values, and trade-offs among values pertinent to the design; empirical investigations using social-science methods to uncover how stakeholders think about and act with respect to the values involved in the system; and technical investigations which explore the links between specific technical decisions and the values and practices they aid and hinder.

For example, Friedman et al. applied principles of VSD to a redesign of the open-source Mozilla browser to provide peripheral awareness of cookies, as well as just-in-time information and management of individual cookies and cookies in general.[15] The redesign emphasized a balance of both values about privacy and informed consent, and the importance of minimal distraction from the task at hand.

Inspiringly for us, VSD brings values questions into the design practice, not just from what stakeholders want but based on deeper questions about what values should be thought about and what values are, consciously or unconsciously, shaping the design. For Friedman et al., the core values to examine and include are values related to human justice, well-being, welfare, and rights. While these values are important for us, we propose critical reflection in and of itself as a core value for technology design.

Critical Design

Critical design is an approach to design research developed by Tony Dunne and Fiona Raby [e.g. 11,12]. Dunne and Raby's goal is to push design research beyond an agenda of simply reinforcing values of consumer culture and to instead embody cultural critique in designed artifacts. A critical designer designs objects not to do what users want and value, but to introduce both designers and users to new ways of looking at the world around them and the role that designed objects can play for them in it. This approach is also related to a variety of art-based practices, such as those discussed in [24].

The Dawn Chorus, a speculative design by Bill Gaver and Heather Martin inspired by the critical design approach [21], illustrates the principles of critical design within the HCI context. The Dawn Chorus is a bird feeder that classically conditions birds to sing your favorite songs, from Britney Spears to Beethoven. It uses the critical design strategy of ‘value fictions.’ As opposed to science fiction, which assumes existing values while projecting new technology into the future, value fictions assume existing technology but project a new set of values that are embodied in them. In the case of the Dawn Chorus, the value of human dominance over animals is embodied in a personal, living music box. The extremity of this design provokes reflection on our existing practices of domination over nature and the role of technology in this drive.

Critical designs do not necessarily need to be built; just the idea of the object itself can be enough to encourage reflection. Furthermore, although critical designs have the potential to spark reflection by users, they are often directed at designers themselves, to defamiliarize and thereby open up design practice. These values are essential for reflective design.

Unfortunately, the provocative nature of critical design can backfire if people miss the ironic or subtle commentary. On the one hand, this may result in people simply discounting the design as ridiculous or extreme but without examining why. On the other hand, people may use the design as evidence of support for the very values on which it is attempting to cause critical reflection. For these reasons, we want to draw from the provocative, critical practices of critical design but in a manner that provides more footholds for including users and well as designers in the debate. In doing so, we have been inspired by the uptake of critical design into ludic design.

Ludic Design

Ludic design, developed by Bill Gaver, is the notion of designing for *homo ludens*: people as playful creatures. It recognizes that playful or ludic activities are not merely a matter of entertainment, or a waste of time, but can be a ‘mechanism for developing new values and goals, for learning new things and for achieving new understandings’ [22]. Ludic design promotes engagement in the exploration and production of meaning, providing for curiosity, exploration and reflection as key values. In other words, ludic design focuses on reflection and engagement through the experience of using the designed object.

For example, the Presence project [20] developed a series of electronic installations to support engagement of elders with their environment in the Bijlmermeer, a low-income housing project in the Netherlands with a poor reputation for crime. 'Slogan benches' were installed throughout the project, which provided both a place to sit and a place to reflect on built-in, rotating slogans that had been submitted by elderly residents. Rather than focusing on task-oriented functionality, which might highlight issues of safety or education, the designers focused on displaying the commentary of the local residents, who often saw their lives in much richer ways than the neighborhood's reputation would suggest. The slogan benches were

accepted with enthusiasm and did appear to serve as a point of reflection for the community.

In the context of HCI, ludic design explores the limits of technology design practice - what it is we may design for, what methods we may use - by proposing a specific set of values that contrast sharply with the values currently at the center of technical practice: functionality, efficiency, optimality, task focus. Compared to critical design, ludic design is itself more playful; it carefully avoids preaching to users or ironically bypassing them. Inspired by ludic design, we are interested in further developing its critical engagement and connecting it to ongoing critical traditions in other fields. To do so, we draw on critical technical practice.

Critical Technical Practice

Critical technical practice (CTP) is outlined by Phil Agre in his 1997 book Computation and Human Experience [1], and, unlike the previously mentioned traditions, is grounded in Artificial Intelligence rather than HCI. CTP is an approach to synthesizing critical reflection with technology production as a way of highlighting and altering unconsciously-held assumptions that are hindering progress in a technical field.

Agre sees CTP as a way to solve recurring technical impasses by enabling reflection on, and potentially alteration to, the core metaphors that structure a technical field. Briefly, CTP consists of the following moves: identifying the core metaphors of the field, noticing what, when working within those metaphors, remains marginalized, inverting the dominant metaphors to bring that margin to the center, and embodying the alternative as a new technology.

It is important to note that during this process, the values embodied by the field can be questioned and shifted. Collaborating with David Chapman, Agre critiqued the dominant planning approaches in Artificial Intelligence (AI) as offering an impoverished understanding of human behavior. Agre and Chapman inverted a core metaphor of AI, namely abstract cognition, to open a new design space for AI; their work became an influential part of the new 'situated action' paradigm. In this work, CTP functioned to bring to the fore and make meaningful in technical discourse aspects of human activity that were previously marginalized from design.

CTP is a key method for reflective design, since it offers strategies to bring unconscious values to the fore by creating technical alternatives. In our work, we extend CTP in several ways that make it particularly appropriate for human-computer interaction and critical computing.

First, critical technical practice for Agre is primarily about strategies for designers to reflect on their design practice. We extend CTP to also encourage users to reflect on their use of technology and the design of technology.

Second, for Agre CTP is called into action only during a technical breakdown or impasse – i.e. reflection is only needed when a core metaphor is no longer adequate. We believe the value of CTP extends beyond this and can be employed throughout the design and use cycle. All designs have centers and margins, all are based to some degree on a constitutive metaphor. The process of exploring the limits of design need not wait until a technical impasse requires reflection.

Finally, Agre sees CTP as primarily a means to ensure technical progress by avoiding getting stuck in impasses. For him, CTP should be driven by technical problems, with critical reflection as a means to technical ends. We see it instead as simultaneously driven by technical and critical concerns, allowing us to raise and explore value questions in our technical work.

Reflection-in-Action

As a final foundational category, we draw on the concept of reflection-in-action outlined by Donald Schön [36] and echoed in recent HCI work on embodied interaction [9] and dialogical experience [32]. Schön proposes reflection as an active, in the moment, and almost intuitive, visceral process as opposed to a detached cerebral analysis occurring pre or post engagement. A quintessential example for Schön is how an architect works within the complexity and constraints of a given context: approaching a defined problem with methods and tools of their training yet open to the situation's 'back talk.'

Responding to back talk require reflective practitioners to be willing to change the frame of a problem space. In this effort, reflection-in-action provides a ground for uniting theory and practice; whereas theory presents a view of the world in general principles and abstract problem spaces, practice involves both building within these generalities and breaking them down. The everyday imagination and improvisation emphasis of reflection-in-action suggests why it has been taken up extensively in HCI and CSCW both as a guide for designers [14,30] and as a template for the types of activities a collaborative system should support. [27,**Error! Reference source not found.**].

Schön's metaphor of conversation with the situation shares similarities with current experience-focused approaches in HCI. McCarthy and Wright [32], for example, propose that design should avoid the reification of experience in preference for supporting the dialogical nature, the emergent unfolding of experience. They illustrate the tension between theorizing experience into a static or known phenomenon and the practice of leaving room for change and the unknowable. For instance, situational theories often become categorical imperatives within which the uniqueness of the individual, and the 'felt life' of a particular situation, is lost. Dourish explores this same challenge within HCI in terms of designing *for* experience as opposed to designing experience *into* an interface or application. For example, context-aware systems often attempt to model context into discrete, knowable, and

transferable information; whereas for Dourish, context emerges and is enacted in action.

We draw several points of inspiration from reflection-in-action, but also several points of divergence. Reflective design, like reflection-in-action, advocates practicing research and design concomitantly, and not only as separate disciplines. We also subscribe to a view of reflection as a fully engaged interaction and not a detached assessment. Finally, we draw from the observation that reflection is often triggered by an element of 'surprise', where someone moves from knowing-in-action, operating within the status quo, to reflection-in-action, puzzling out what to do next or why the status quo has been disrupted.

We expand on reflection-in-action by not waiting for surprise to occur but by intervening to create or stimulate these reflection triggers. What we want to avoid however is a literal codification of reflection-in-action, for example pop-up windows that suggest 'now would be a good time to think about what is happening…''. Finally, as with all of the foundational areas we draw from, reflection-in-action offers one lens for reflective design.

Our attempt is to draw from the range of practices and approaches outlined thus far. It is an integrated approach: reflective design does not replace these other rich approaches. As research in these traditions continues, we can continue to draw from them as a resource, examining how their insights play off each other, or even against each other, to lead to new ideas for reflective design.

DESIGN CASE STUDIES

In the previous sections, we outlined why reflective design is an important practice, indeed a core principle and outcome for technology design. In developing our stance, we have drawn from several foundations. At this point, however, it may be helpful to concretize our approach with our own attempts to embody reflective design. We will discuss two case studies, united by the underlying objectives but dramatically different in their target audience and ultimate enactment. Both case studies are works in progress and described only briefly here, for more elaborate accounts, see [7,8,28,28].

Case Study I: Reflective Design in the Art Museum

With Geri Gay of the Human Computer Interaction Group, authors Boehner and Sengers have been exploring the design of technology, in particular mobile and context-aware computing, for art museums. New technology in the art museum tends to function either as art itself, such as a digital installation, or as a tool for learning about the art on display. When used as tool, such as a mobile tour guide, the objective of the technology is often described as 'optimizing' the museum visit by providing more information or customizing this information for a particular visitor style [**Error! Reference source not found.**]. This relatively circumscribed view of technology in the art museum provides an interesting context for reflective design.

By designing primarily for the one-way transfer of information about art from experts to novices, many aspects of the visitor experience are left largely underdesigned for: e.g. liminal, social, spiritual, and emotional experiences of being in and moving through a physical space amid the presence of others. These experiences contribute to the museum but tend to be left out of the technical specification. Rather, 'optimizing' with regards to technology still takes on language such as providing 'just-in-time' information or providing a clear path to the right (e.g. most popular) object.

We set out to create new designs to incorporate familiar, but under-designed for, aspects of the museum experience. One of our earliest attempts was to simply provide a comment channel on the handheld tour guides for visitors to add their own voice to the curator's voice [**Error! Reference source not found.**,6]. The somewhat limited and reserved use of this channel forced us to realize how dominant the frame of the 'optimal' museum experience is. When we asked visitors why they chose not to leave comments, a common category of response was "I don't feel like what I have to say is of value." In other words, simply using the technology to provide a new channel for visitor expression is not enough to encourage or provide license for participation. It's not only museum staff and technology designers who see technology as serving information from experts to novices, but visitors are also conditioned to expect and adopt this role.

Therefore, our next series of designs for museum spaces sought to augment familiar practices in the museum, practices that have faded into the background but are engaged in regularly. Many of our designs focus on exposing the presence of unknown others who often shape one's experience without one's complete awareness. Some of our designs have attempted to do this in an ambient and somewhat ambiguous way – using a cloudscape to represent the collective mood in the museum for example, or using bird sounds to mark areas in the gallery of non-presence or contemplation.

In a more literal installation, we created an application to augment how visitors implicitly comment on displayed art simply by choosing or not choosing to engage with a piece [8]. For this end, we asked visitors who checked out a handheld tour guide to create a digital imprint that would mark their tour. Each time they selected an object to learn about, the visitor's personally designed imprint was left behind with that object. Therefore in addition to asking questions such as: who made this object?, or how was it made?, the visitor could also ask: who else visited this object? (Figure 1) exposing the range of visitor imprints. One visitor remarked of the experience: "I saw that at one object, there was only one other visitor. And I wondered if maybe they were a kindred spirit."

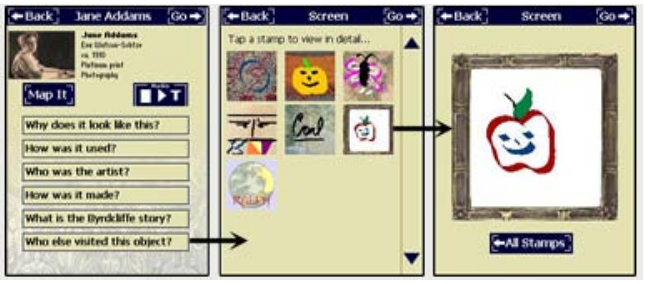

Figure 1. Three screen shots on a handheld museum tour guide for the question "Who else visited this object?"

In these projects, the approach of reflective design led to conceptualizing a new space for design. We began by reflecting on the recursive feedback loop of technology design for museums, where how we define the (dominant) museum experience influences what we design for, and how what we design for in turn re-inscribes the dominant museum experience. In designing for marginal experiences, we wanted visitors and curators to reflect on these under-designed for aspects. In the handheld tour guide, for example, we raised the profile of information about other visitors to the level of information about the art.

By presenting this case study of technology in the museum, we can begin to illustrate how reflective design adds to the foundational approaches described earlier. Had used only the lens of PD, VSD, or CTP, this study would not exist. For CTP, there was no technological impasse to overcome, handheld tour guides deliver information reasonably well. With PD or VSD, visitors or curators would have had to initially ask for alternate experiences with technology. Our argument is that the marginal experiences are so implicit that their value may not be accounted for until experienced in alternate ways.

If we came to the museum context armed only with critical design, we likely would create something that played the role of art itself, therefore continuing the dichotomy of technology in the museum as either art or information about art. The practice of reflection-in-action reminds us what we want to create but not how to go about doing this or where to start. Finally, the approach of ludic design on its own may have led to the resulting designs. However, the additional grounding of critical theory provided insights into the politics of the museum space and encouraged us to move from designing new experiences and to augmenting existing experiences in new ways.

Case Study II: Intimate Objects

Our second case study in reflective design began with the question: how can we build technological devices to communicate intimacy for couples in long distance relationships? This was inspired first by Kaye's (the project lead) and his co-authors' personal experience of being in such relationships. The eventual shape of the project was further influenced by examining and challenging traditional design objectives for communicating electronically across a distance.

While HCI builds for the user, and CSCW builds for the group, there was no tradition of building for the couple. Communication devices are often expected or designed to scale in the manner of Metcalfe's Law: the more of them, the more valuable they are. What happens, however, when we build a communication device that doesn't scale? How could we even evaluate a system that claimed to transmit something as complicated to measure as intimacy?

We conducted in-depth interviews with couples in long distance relationships, having them reflect on aspects of their current relationship, technology use within that relationship, and having them sketch novel designs for communication devices for couples to use [28]. We drew on the results of our interviews, our reflections, and on others' exploratory work [39,30,etc.] to develop the concept of the minimal intimate object, which uses the minimal bandwidth possible, one bit, to communicate intimacy.

We weren't sure if it was even possible to communicate something as important and deep as intimacy using a single bit. To use our system, each member of a couple installed our Virtual Intimate Object, or VIO, which appeared as a small circle in the taskbar of the user's Windows screen.

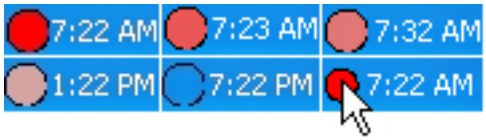

Figure 2: Virtual Intimate Object (VIO) in taskbar, showing color changes over a twelve hour period. Note initial rapid fading in top line. Final image shows display of remote partner's button state on mouseover.

When one member clicks on the circle, their partner's circle changes to bright red. As shown in Figure 2, the circle dims quickly at first, and then fades slowly over time. Eventually, it returns to transparent twelve hours after the circle was clicked. Pressing the button again restarts the cycle at maximum light intensity. Moving the mouse over the circle without clicking shows the current status of the remote partner's circle.

In user testing these devices we wanted to explicitly encourage three types of reflection: reflection on the device and its use, reflection on the relationship, and reflection on the study. We recruited five couples in long distance relationships. To support and encourage this reflection, we had our users fill out a logbook on a daily basis: rather than being an extraneous evaluation, we came to understand that this logbook use and corresponding reflection was an intrinsic part of the experience of using the VIO.

The logbook consisted of open-ended questions inspired by cultural probes [19] and Likkert-scale questions about the users' relationship, about their attitude and use of the VIO, and about the study. In many ways, these were straightforward suggestions that were instrumental in our understanding of the next version of the software – such as

asking users what they would change about the VIO. However, we saw the logbook as a way of encouraging the users' active role in interpreting and appropriating the VIO.

We used playful and open questions as an additional strategy to invite more active participation. For example, we asked users when they used their IO, what sound it would make if it could make one, and to draw a picture of what their ideal IO would look like. We asked them to rate how intimate, embarrassing, and enchanting the VIO was on a 7-point Likkert scale - and to pick two other metrics, and rate the VIO on those metrics. This question gave an opportunity for users to express both their enthusiasm and their skepticism with the intimate objects, but in an interesting way: fore example, one user wrote that they felt the VIO was "*driving us apart"* – but rated it only 4 out of 7. In traditional survey design, a 4 is a middle-of-the-road response, and is often read as being no data. The combination of metrics and ratings gave an opportunity for users to express their skepticism to the researchers in their choice of metrics, but hide behind an ambivalent rating, in a manner akin to sarcasm or irony. [28]

Finally, we included questions asking our users to reflect on the study itself. Some were short-answer questions, which still gave us a strong impression of how some of our users felt: "What would you name the people conducting this research?" gave answers as varied as "*Mysterious Watchers*" and "*Intimacy Dream Team*". Others asked the users for a better way to do the study, or what they thought the research was really about. One user accused us of "*Creating computer dependency and spreading and marketing it to the general public*". We found this (hopefully good-natured) skepticism a sign that we were successful in encouraging rich reflection.

The results of these reflections were a key part of our evaluation. We knew from our server statistics that the intimate objects were being heavily used at least some of the couples, and so by purely objective, numerical standards we felt the project was a success. However, the diaries gave us both a strong understanding of the phenomenological or felt experience of VIO use as well as a concrete understanding of our next steps in the project, including changes in the software, such as the addition of configurable sound, or the ability to change the color or icon displayed, as well as in the experimental design, such as the need for exploring the phenomenological experience of the survey itself separate from the experience of the intimate object.

DISCUSSION

These case studies are works in progress but provide an illustration of both the types of projects reflective design inspires and how this approach informs their development. In this section, we begin articulating principles and strategies that worked well for each case as well as principles and strategies that would help advance them further. We end by identifying some of the challenges of reflective design.

Principles of Reflective Design

The following core principles are derived both from our case studies as well as the foundational perspectives of reflective design discussed earlier. These principles are not exhaustive but a beginning formulation.

1. Designers should use reflection to uncover and alter the limitations of design practice. The most basic principle of reflective design is to use reflection to identify unconscious values and assumptions that are built into the very way we conceive of design problems, to analyze what practices and values are marginalized in HCI practice, to develop methods to bring marginalized practices to the center of HCI, and to stimulate debate on the activities and values HCI practitioners can and should support. For example, in the Intimate Objects study, designing for couples highlighted the assumptions of single-user design in HCI, opening up a space for design between that tradition and the groupware of CSCW.

2. Designers should use reflection to re-understand their own role in the technology design process. The previous principle highlights designers' use of reflection to understand the limitations of the field as a whole. But critical theory argues that all of our personal experiences are informed by unconscious influences. This suggests designers should aim to make conscious the personal preconceptions that are shaping their approach to design. What values and experiences is the individual designer bringing to the table? What would he or she like to share with users? We explored this principle in its extreme with the autobiographical approach to the Intimate Objects design. Three of the authors' long-distance relationships provided a rich resource for reflection, not just on the authors' own needs as users, but on the relationship between their role as users and their role as designers of the technology.

3. Designers should support users in reflecting on their lives. The central aim of the critical project is to enhance human freedom by supporting critical reflection. Technology designers can play a strong role in this project by offering users new ways of experiencing and reflecting on their activities. Technology can be designed, for example, to highlight the choices one makes in everyday activities and to offer up new choices that may not have been in the user's awareness. In the museum, curators and visitors came to the design process with the mutual understanding that visitors would be passive receivers of information about the art. The goal for our design was to question these cultural norms and open up a space where it was comfortable for users to experience their relationship to museums in a different way.

4. Technology should support skepticism about and reinterpretation of its own working. Technologies are not inherently values-blind: they optimize for different points of view, for different assumptions about optimal,

assumed and allowed uses and users, and for differing values. As part of the critical project, it is essential that we as designers work, not only to support users in reflecting on their activities, but to leave open a space for them to reflect on, and perhaps reject, how our technology is influencing their choice of activities and their engagement in these activities, and to feel empowered to re-appropriate the technology for alternate ends. Technology that monitors and reports on user activity or experiences should be carefully designed to avoid making the technology, rather than the user, the final authority on what the user is doing.In the Intimate Objects study, participants were explicitly encouraged in their journals to redesign and rethink both the technology and the study of the technology.

5. Reflection is not a separate activity from action but is folded into it as an integral part of experience. Heidegger [25] argues that we use tools such as a hammer unthinkingly, until they break. This argument has been understood in HCI to suggest that usability of a tool is antithetical to reflection on it [9]. But critical theory argues that critical reflection is effective only when it is, rather than an intellectual practice separate from action, immediately folded back into our experiences, actions, identities, and practices. This suggests that we should not design for reflection as a stand-alone activity but as one component of a holistic experience which also includes ongoing activity [32]. In the museum, user information is traditionally of use only for curators as a type of post-hoc reflection and evaluation. We believe this same information on visitor patterns and preferences can provide an ongoing opportunity for everyday, open-ended reflection for the users on their own activities.

6. Dialogic engagement between designers and users through technology can enhance reflection. It is easy to imagine 'reflective design' as a designer standing aloof, benignly passing down opportunities for reflection. Following PD, VSD, and ludic design, however, we recognize that design is a process of learning about the existing limitations and future possibilities for design from and with users. As Asaro [2] argues, a collaborative process of design forces both users and designers to grapple with the material properties of technology and with each other's agendas in ways that can stimulate critical awareness. Users bring perspectives that can highlight what is missing from HCI; in turn, designers can share their reflective concerns about technologies and the activities they support with users. In the museums project, we learned quickly to rethink our initial idea that users would be enthusiastic to adopt new practices in the museum. Instead, we began to think through how we could create a kind of digital scaffolding: building new practices on existing practices with which users felt more comfortable.

Reflective Design Strategies

In addition to helping us shape our principles or objectives, our foundational influences and case studies have also helped us articulate strategies for reflective design. The first three strategies identified here speak to characteristics of designs that encourage reflection by users. The second group of strategies provide ways for reflecting on the process of design. We anticipate that this list will continue to grow as we work with reflective design in the future.

1. Provide for interpretive flexibility. Reflective design allows users to maintain control of and responsibility for the meaning-making process. This requires actively building for co-construction of meaning between users, systems, and designers. This can be accomplished a variety of ways: actively setting out to make the familiar strange [3], introducing and encouraging ambiguity as a resource and not as a factor to be eliminated [18], and building open-ended systems where the reflection itself is an irreducible part of the final experience.

2. Give users license to participate. Although one of the methods in the previous strategy is to make the familiar strange, our experiences have shown us that this must be balanced with a license to participate. Presenting the strange or the unfamiliar may alienate, confuse, or simply not interest people, so this must be done in a way that gives footholds for interpretation. We refer to this as providing a digital scaffolding for bridging from the familiar to the unfamiliar. One method is to use playfulness in a way that makes people feel included. Another method is to ground the strange in the familiar – such as with the museum applications where we used a familiar practice of choosing what objects to look at, but represented this familiar practice in a strange way.

3. Provide dynamic feedback to users. The idea of presenting visitor information back to visitors themselves as a way to give license to participate is related to the strategy of providing dynamic feedback. By this strategy, we mean that whatever information is collected about or from users can provide a useful stimulus for reflection, whether this is for input to the system or for evaluating the system. In the museum example, we presented visitor patterns and preferences back to visitors themselves in addition to using that information as input for the system design (as well as input to curators for evaluation). In the case of the Intimate Objects, the couples' journal is both a tool for collecting data about their experience for the evaluator, but also a tool for reflection by the couples as they use the device.

4. Inspire rich feedback from users. Reflective design encourages making evaluation and reflection an inherent part of the design, not merely a step added on at the end. Part of this process is recognizing that any evaluation method dictates the form of the design it is evaluating. Even 'objective' methods of evaluation – such as those that seek to minimize the duration or maximize the efficiency of the task – require that the task be formed in such a way that these metrics can be measured. Similarly, it is possible to

design an evaluation mechanism that itself inspires users' reflection, and that reflection can provide valuable and rich feedback in addition to that provided by the technology.

5. Build technology as a probe. Reflective design uses built systems analogous to the way a social scientist using an experiment. In a social science experiment, the experimental design is constructed so as to learn about some aspect of the human condition. This strategy is similar to technological probes [26], where new technology acts as a stimulus or probe for understanding larger social practices, such as communication patterns evolve. Unlike most social science research, our experiments are not only about understanding users and the effects of technology in use, but also about reflecting back on the practices of technology design and evaluation.

6. Invert metaphors and cross boundaries. Directly from the critical technical practice approach as well as more general interdisciplinary research, we use the idea of the constitutive metaphor (and metaphors in general) to help find new design spaces. Inverting traditional assumptions and looking to practices that are left 'undesigned for' is a wealthy source of inspiration.

Some Reflective Design Challenges

The principles and strategies of reflective design, as a technical practice, create their own centers and margins. As we outline what we define as the center of reflective design, we must also identify the margins, both in terms of what we are struggling with and what we have, to some degree, marginalized in importance.

First, many of the strategies listed above lead to a variety of possible design interventions, but don't necessarily give guidance in terms of when one intervention will be better than another. For instance, inverting a design metaphor is often not a simple matter of doing the opposite, but doing something different. Anticipating the value of these different choices is something for which we need criteria. VSD is instructive here, in terms of choosing designs that value human flourishing and justice, but what about two competing designs that do both in radically different ways?

Furthermore, this issue of guiding design choices leads to evaluation issues. A design choice suggests that a design will be used in accordance with this choice, but in reflective design we are purposefully designing for appropriation. An interpretively flexible system, where meaning is co-constructed by users and designers, does not have an a priori benchmark of what "works". We want to evaluate our systems phenomenologically, i.e. allow for new interpretations and uses, yet we still want to be able to say when a design has failed. Methods to do so are still under development [38].

Designing for appropriation requires recognizing that users *already* interact with technology not just on a superficial, task-centered level, but with an awareness of the larger social and cultural embeddedness of the activity (see [32] for a rich treatment of this topic). Much traditional technology design treats the user as a 'technological dope', analogous to Garfinkel's 'cultural dope': an automatic, almost reflex substantiator and re-enactor of cultural norms, with little recognition of the individual experiences, awarenesses and reflection that a given person brings to the table [17]. Our designs and evaluation must avoid this kind of abstraction of users and designers.

These issues of design criteria and evaluation help indicate where our margins lie. In addition, reflection in general is a loosely defined construct. We recognize that reflection by users, by designers, by evaluators, and reflection in use and on both the activity and the technology can seem all-encompassing and recursive. As we define our principles and strategies further, we look to more clearly delineate where, when, and how reflective design can be used effectively in HCI.

However, we do recognize the boundaries in our approach are clearly drawn in terms of the scientific goals of validity and generalizability. Because we begin with an interest in designing for rich experiences and avoiding the abstraction of messy complexity into reproducible bits, we tend to choose ecological validity over measures of generalizability. Nevertheless, we believe these individualized samples provide a richer lens onto phenomena that are otherwise in danger of being anemically simplified.

CONCLUSION

As emotive, social, and spiritual beings, people continuously sense and respond to technology in complex ways. Designers have an opportunity to embrace this complexity by questioning and highlighting values and practices of their technology design.

In the examples above, we have shown how it is possible to question values currently embodied in computational systems to produce technological systems that are meaningful to users. In doing so we drew from existing critical approaches, which we combine into the framework of reflective design. As we have outlined, reflective design is a set of design principles and strategies that guide designers in rethinking dominant metaphors and values and engaging users in this same critical practice.

ACKNOWLEDGEMENTS

The term 'reflective design' was developed in collaboration with Kat Becker, Jeremiah Fairbank, and Jason Lee. This work is partly funded by National Science Foundation grant 0238132. Thanks to all our Culturally Embedded Computing Group members, to the HCI Group, the People & Practices Group at Intel, and to Geri Gay, Mark Blythe, Paul Dourish, Bill Gaver, Kristina Höök, Michael Mateas, Simon Penny, & Peter Wright. Special thanks to the anonymous reviewers for useful comments and criticisms.

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