The Role of Cultural Forms in Tangible Interaction Design

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ABSTRACT
I suggest an approach to tangible interaction design that builds on social and cultural foundations. Specifically, I propose that designers can evoke *cultural forms* as a means to tap into users' existing cognitive, physical, and emotional resources. The emphasis is less on improving the usability of an interface and more on improving the overall experience around an interactive artifact by cueing productive patterns of social activity. My use of the term cultural form is derived from the work of Geoffrey Saxe and his form-function shift framework. This framework describes a process through which individuals appropriate cultural forms and restructure them to serve new functions in light of shifting goals and expectations. I describe Saxe's framework and then illustrate the use of cultural forms in design with three examples.

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Tangible interaction, design, cultural forms

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H5.2. User Interfaces: Theory & Methods.

INTRODUCTION

How do we design for situations in which the quality of social interaction is at least as important as usability? In places like museums, parks, coffee shops, and living rooms, social arrangements can be fluid and unpredictable, and friends and families often mix with strangers and crowds [10, 11, 12, 21, 22]. Productively engaging groups of people in these settings (and not just individuals) can be critical to the success or failure of a design. What tools, then, do we, as designers, have to help structure the activity that takes place *around* an interactive system? Many researchers have considered this question from various perspectives (e.g. [11, 12, 22, 27]). Don Norman proposes the use of *social signifiers*, which he defines as perceivable cues that suggest social activity or appropriate social behavior [27]. Likewise, Hornecker elaborates on the theme of *embodied facilitation* as a means to "influence behavior patterns and emerging social configurations" [11].

In this paper, I expand on these ideas and suggest an approach to tangible interaction design that builds on cultural foundations rather than on more universal aspects of human experience with the physical world. I propose that designers can intentionally shape objects and situations to evoke *cultural forms* as a means to activate patterns of social activity as well as rich cognitive, physical, and emotional resources.

My use of the term cultural form is derived from the work of Geoff Saxe and his form-function shift framework [29, 30]. This framework describes a process through which individuals can appropriate existing cultural forms and restructure them to serve new functions in light of shifting goals and expectations. The term *cultural form* refers to social constructions or conventions that are linked to recurrent patterns of activity. Examples include things like counting systems, games, and currency systems. Cultural forms often involve the use of physical artifacts (as in card games), but they can also consist entirely of patterns of social activity (as in games like hide-and-seek). The use of cultural forms is especially relevant to tangible interaction because physical and social embodiment [4, 11, 12] provides designers with unique opportunities to shape artifacts, situations, and environments to evoke cultural forms in highly recognizable ways. I describe Saxe's framework in more detail below. Then, through three examples, I argue that it is possible to create tangible systems that build on cultural forms while at the same time suggesting novel functions and capabilities for which they might be used.

A Thought Experiment

Before getting too far into the details, a short thought experiment might help illustrate what I mean by cultural forms. To begin, imagine a small group of elementary school children in a room. Now, imagine that a researcher walks into the room, places a coil of rope on a table (Figure 1, left), and then leaves without saying anything. What happens next? Maybe the kids

Figure 1. A thought experiment.

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play with the rope; maybe they tie it in knots or play tug-of-war; maybe they swing the rope around; or maybe they just ignore it altogether. The point is that it's not easy to predict what will happen, and it probably depends a great deal on the kids themselves and the dynamics of the group.

Now let's repeat the experiment. As before, there's a small group of children in a room. A researcher places a coil of rope on a table and then walks away. The difference is that this time there are wooden handles attached to the two ends of the rope (Figure 1, right). What happens now? The outcome will still vary depending on the kids themselves, but we can be a bit more confident in predicting the outcome. We might see individual kids jumping rope, or maybe two kids will swing the rope while a third tries to jump in time. Depending on where the kids come from, they might sing rhythmic songs or enact elaborate rules for taking turns.

So what changed between the two trials? We might argue that the *affordances* of the object changed, that the handles attached to the rope now afford grasping, swinging, and jumping. But this explanation is unsatisfactory. After all, a rope without handles can still easily be used as a jump rope. A slightly different explanation is that the kids now *perceive* the object in a different way. In this interpretation, the rope with handles affords jumping whereas the rope without handles does not. And, while this might be an acceptable interpretation, the use of the term *affordance* places an emphasis on the object itself and how the object might be *used*. But, what's interesting about this example is not the rope, or even that the kids jump with it. What's interesting is the social interaction that effortlessly coalesces around the jump rope as a cultural artifact. As Norman points out, the concept of affordance fails to capture the full implications of phenomena like this [27]. The explanation I propose is that the rope with handles evokes a strong and recognizable cultural form, which, in turn, activates intricate patterns of social activity. It also activates associated physical, cognitive, and emotional resources individuals can apply to the situation. Below I expand on these ideas and illustrate the use of cultural forms in tangible interaction design with three examples.

BACKGROUND

Much of the research on "natural" and "intuitive" interaction emphasizes universal aspects of human experience, such as sensorimotor interaction with the physical world and cross-cultural metaphors. And, while this focus on universality might be valuable for creating broadly applicable designs, it also underplays the substantial role of cultural influences in shaping our understanding of the social world. Furthermore, as Hornecker points out, even though much of the excitement surrounding tangible interaction has to do with its supposed ability to facilitate collaboration, we lack design tools that help put existing patterns of social activity to use in creating effective collaborative interaction [11].

Hurtienne & Israel [14] acknowledge the role of cultural in their continuum of pre-existing knowledge, which includes innate knowledge, sensorimotor knowledge, cultural knowledge, and knowledge derived from domain expertise. However, they explicitly emphasize the sensorimotor end of the continuum in an effort to be more universally applicable. As they put it: "the further we rise towards the top level of the continuum, the higher the degree of specialization of knowledge and the smaller the potential number of users possessing this knowledge gets." [14] (p. 128).

Hurtienne & Israel have also contributed to recent interest in the use of *embodied metaphor* as a foundation for intuitive tangible interaction design [1, 2, 14, 15, 19]. This work builds on theories of embodied cognition (e.g. [17]), which suggest that everyday sensory-motor experiences, starting in infancy, form the metaphorical foundation through which we understand a wide variety of abstract concepts. Much of the appeal of embodied metaphor comes from the idea that we can take advantage of emerging interactive technology to design more intuitive mappings between physical actions and abstract concepts. As such, this research has focused on universal aspects of human experience that cut across cultural contexts (e.g. metaphor population stereotypes [15, 19]).

The Reality-Based Interaction (RBI) framework proposes that interaction designers can build on our understanding of the natural world at four levels: naïve physics, body awareness and skills, environment awareness and skills, and social awareness and skills [16]. The RBI framework provides several examples that take advantage of social awareness and skills, but it does not offer specific guidelines for activating these skills on the part of users. Likewise, research on Natural User Interfaces (NUI) emphasizes interaction that can create "fluid, natural experiences by mimicking real-world physical interactions and augmenting them beyond what is possible in the real world" [36]. Wigdor and Wixon also point out the growing importance of support for co-located social interaction in NUIs [36].

Through case studies, Hornecker presents a critique of the assumption that tangibles are more natural or intuitive due to affordances rooted in physicality and our everyday experiences with the real world [13]. Hornecker argues that "relying on affordances in design is far from straightforward." Not only can "affordances […] go unnoticed if they *do not* fit with real-world experience and cultural knowledge" but it is also difficult to "restrict the set of affordances of a physical interface to those intended by the designer" [13].

Dourish's notion of embodied interaction captures the relationship between interaction, objects, and meaning as it is constructed through social and cultural practice: "The analytic exploration of embodied interaction has repeatedly uncovered the way that objects carry meaning on multiple levels: as entities in their own right, as signifiers of social meaning, as elements in systems of practice […]" [4] (p.166). Norman's notion of *social signifiers* also suggests that we can take advantage of perceptible indicators in the physical or social world to cue productive social activity [27]. Likewise, Hornecker describes ways in which designers can support *embodied facilitation*: "We can interpret systems as spaces or struc-

tures to act and move in, thereby determining usage options and behavior patterns" [11]. Hornecker's specific strategies include offering embodied constraints, multiple access points, and tailored representations [11].

Many researchers have argued that it is important to design systems that are responsive or sensitive to existing patterns of social activity (e.g. [3, 4, 8, 11, 12, 18, 20-22, 27, 33, 34]). An influential example is Mackay's study of work practices of air traffic controllers surrounding their use of paper flight strips [20]. She concludes that "[t]he current paper-based system supports safe and effective work practices and offers a level of flexibility difficult to imagine with traditional computer-based interfaces" [20] (p. 336). Her argument is that for safety-critical systems, computer-augmented tools must work in concert with existing work practices that have evolved over long periods of time. Another example is Dillenbourg's concept of *classroom orchestration* [3]. Dillenbourg argues that technology should both work with and augment existing classroom practices in order to support usability at the level of the classrooms, not just at the level of individuals or small groups [3]. Similarly, Lee's *cultural modeling design framework* [18] advocates for the design of learning environments that are responsive to school students' cultural funds of knowledge [8] and socially constructed ways of knowing. She demonstrates the application of this framework in the design of a multimedia literacy environment that is responsive to the sociocultural resources of students in schools [18].

Form-Function Shift Framework

My use of the term "cultural form" is derived from the work of Geoff Saxe and his *form-function shift* framework [29, 30]. Briefly, Saxe's framework integrates individual cognitive development with changes that take place at the level of communities and cultures. He developed his theory through the study of diverse groups of people engaged with culturally specific concepts and artifacts. These groups included children selling candy on city streets in Brazil; adults engaging in economic exchanges with Western currency systems in remote areas of Papua New Guinea; and children studying fractions in elementary schools. Using these studies as a foundation, Saxe explains how individuals can appropriate existing cultural forms and restructure them to serve new functions over time in light of shifting goals and expectations.

Cultural Forms

Central to Saxe's framework is the notion of cultural forms, which he defines as historically elaborated social constructions and conventions [29]. Examples include things like counting systems, games, and monetary systems. Cultural forms commonly involve physical artifacts (as in activities like jumping rope), or they can consist entirely of patterns of activity (as in games like hide and seek). Saxe describes cultural forms as inherently linked to social practices. In other words, artifacts like a jigsaw puzzle or a $20 bill are nothing more than bits of paper and cardboard in the absence of recurrent, socially organized activities (practices) that give them meaning. So, when I open a jigsaw puzzle box and dump the pieces on a table, I not only have a specific goal in mind (assembling the puzzle), I also have a set of physical and cognitive skills that can be coordinated in a routine behavior to achieve that goal. And, unless I happen to be alone, dumping the puzzle pieces on the table is also a communicative act—a sort of open invitation to the people around me to partake in a shared endeavor that involves corresponding social resources as well. These resources include things like establishing common ground, negotiating goals and sub-goals, and resolving disputes.

In a way the jigsaw puzzle is just an excuse to spend time with friends and family—to talk and joke and to be physically close. The broader point is that through cultural forms, people coordinate activities and resources to accomplish goals. However, these goals are diverse, multi-layered, and constantly in flux. "Not only do individuals shape and reshape their goals as practices take form in everyday life, but they also construct goals that vary in character as a function of the knowledge that they bring to practices" [29] (p.17).

My use of the term cultural forms implies social practices and activities that can take place at different levels of granularity. For example, Sherin uses the term *micro-practices* to describe "stereotypical activities, varying in length from a few minutes to a few hours, in which a handful of individuals participate as the main actors." [31]. Micro-practices include things like going fishing, bowling, or playing a board game. Many of the cultural forms that I use as examples in this paper involve social activities that might be better described as micro-practices. Other forms like currency and counting systems might involve practices at a larger grain size.

One last note on cultural forms is that they persist in societies and cultures over relatively long periods of time—at least long enough to achieve a degree of stability. Of course, as cultures and technologies change, new forms arise, old forms die off, and existing forms evolve and transform. One implication of this observation is that in order for forms to persist, they must have some built-in means of self-replication—some way in which they are passed on from person to person over time. For this to happen, the social activities implicit in cultural forms involve elaborate mechanisms for teaching and learning. There are a few excellent examples of this in the Learning Sciences literature. For example, Nasir's study of the sociocultural practices in the game of dominoes reveals remarkably subtle ways in which peers teach each other strategic approaches to play that go well beyond the rules of the game itself [24]. Likewise, Stevens' study of children playing video games in homes describes a variety of sophisticated learning arrangements in which kids teach and learn from each other through play [28, 32].

CULTURAL FORMS IN INTERACTION DESIGN

Using Saxe's shift framework as a starting point, I propose that cultural forms provide a useful foundation for interaction design (and tangible interaction design in particular). If designers can create systems that purposefully *evoke* cultural forms, then there is a possibility to tap into existing resources

that not only increase usability, but also create meaningful experiences with other people *around* an interface [12].

The perspective I propose diverges from notions of affordance and metaphor as they are traditionally conceived in HCI research. Norman describes affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" [25] (p.9). Here the emphasis is on the object itself and ways in which the object might be used. Of course, users must perceive the cultural form in an object or an artifact for it to be useful. If I don't recognize a piece of paper (like a $20 bill) as monetary currency, then it's just a piece of paper. That piece of paper has certain affordances: it affords writing, folding, crumpling, and so on. But as a $20 bill, the paper has meaning in terms of the cultural practices that involve the storing and exchange of currency for goods and services.

Of course, one interesting thing about this example is that both a rectangular piece of paper and a $20 bill can be thought of as cultural artifacts. The important point is that there are different sets of practice-linked resources associated with them. This leads to the second observation that cultural forms are culturally specific. Forms that make sense in one context are not recognized in other contexts, or are not recognized in quite the same way. Likewise, the practices surrounding the same object might be quite different in different situations. As with affordances and metaphors, cultural forms might be more or less accessible to different members of the same group depending on factors like age, gender, background, and individual experiences. For example, expertise or experience in a specific domain might change the meaning and utility of various forms [29]. What may be more interesting, however, is the idea that different forms can be more or less *appealing* or *inviting* to users depending on their background, thus creating emotional responses that color their entire experience with a particular design [26].

Finally, Saxe's framework suggests that cultural forms are malleable and that people are inventive in their use of them. Forms are continually appropriated and restructured by individuals to serve new functions in light of shifting goals and expectations. This opens the possibility that interaction designers can intentionally evoke cultural forms while at the same time supporting novel capabilities. Designed forms can maintain aspects of source cultural forms to a greater or lesser extent; however, the fidelity of the designed system to the source cultural form is critical as it affects the ability of users to recognize the underlying source form. In other words, if a user does not perceive an interactive system to be an instance of a known cultural form, then potentially desirable practices and resources will remain dormant.

RELATIONSHIP TO METAPHOR

The approach I propose is similar to that of metaphor, but the emphasis is different. One typical use of metaphor in interaction design is to draw parallels between common activities in order to suggest productive actions (or suggest the significance of such actions). However, metaphors tend to break down when the familiar domain ceases to match the expressiveness and power of the target domain [4, 13]. As Dourish describes it: "The value of the metaphor is in suggesting some action, or simplifying how the action is carried out; but the action is to be carried out on the referent of the metaphor, not the vehicle. In addition, of course, the computational referent of the metaphor has a set of capabilities that the metaphorical object does not" [4] (p.143).

When an interactive system evokes a cultural form, it is not a metaphorical representation. Rather, it is an actual instantiation of the source cultural form with a certain degree of variation involved. One way to think about this is that no two jigsaw puzzles are exactly alike. They vary in terms of material properties (wood, rubber, cardboard, plastic), shape, size, number of pieces, and so on. Some jigsaw puzzles have a picture that is revealed when the pieces are assembled, and others don't. Some jigsaw puzzles aren't even puzzles at all if one were to apply a strict operational definition. The point is that the concept of a jigsaw puzzle is rather fuzzy, and while we could argue about whether a specific instance is or is not an actual jigsaw puzzle, the underlying cultural form is recognizable in each instance to a greater or lesser extent. Now imagine an interface based on a jigsaw puzzle (e.g. [9, 38]). We could say that this interface uses a jigsaw puzzle metaphor, a mapping that suggests possible operations that can be performed with objects in the system. However, another way to think about it is that the interface (whether physical or graphical) is, in fact, a real jigsaw puzzle, not metaphorical representation of one. It's just that it varies from source cultural form to some extent, and this variation affects the legibility of the source form. Thus, if users perceive the system as a jigsaw puzzle, they can then apply resources to the task of constructing the puzzle. In other words, the goal is not to suggest actions by means of analogy, but to activate resources and pre-existing patterns of social activity. Norman's use of the term "social signifier" is closer to what I mean by evoking cultural forms [27].

EXAMPLE 1: TANGIBLE PROGRAMMING LANGUAGES

One common application of tangible interaction is in the domain of computer programming languages, particularly for learning purposes. It is typical for designers of these lan-

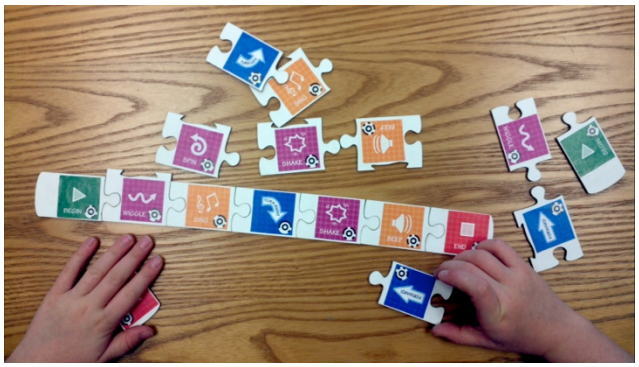

Figure 2. The Tern tangible programming system uses puzzle pieces to allow for the construction of programs.

guages to offer constructive assembly systems [35] for users to build physical algorithmic structures out of a collection of programming components. For example, McNerney [23] and Wyeth [37] created programming systems based on LEGO bricks, while Horn et al. [9] used interlocking blocks shaped like puzzle pieces (Figure 2). Through the use of artifacts like LEGO bricks and wooden blocks, all three of these systems build on existing cultural forms.

I suggest that there is more going on with these systems than simply embodying programming syntax or offering clear affordances and constraints. Because cultural forms are recognizable in these systems, users are able to apply a variety of well-established cognitive and physical resources such as the ability to correctly orient and connect building blocks and the knowledge that construction and assembly are typical goals of such systems [38]. For example, in observations of tangible programming languages, one of the first things children do is to construct the longest possible chain of blocks that they can [9]. This is a goal that is quite consistent with a jigsaw puzzle—assemble all of the pieces to see the hidden picture that results. The forms also activate social resources such as the ability to share blocks, to resolve conflicts over limited resources (e.g. there are only three forward blocks), and to negotiate shared goals.

Continuing with the tangible programming example, different cultural forms may be more or less accessible to different user groups based on background and prior experience. So, for example, it's possible to imagine a child who frequently plays with LEGOs but has never encountered a jigsaw puzzle before. For this child, the resources associated with the LEGO bricks might be more elaborate and practiced than those associated with the puzzle pieces. And, importantly, the three programming systems invoke a set of emotional resources associated with the source forms such as the enjoyment of play.

This leads to the idea that cultural forms that may be more or less inviting to users. For example, Horn et al.'s [9] study of tangible programming systems in a science museum found that the tangible system was more inviting than an equivalent graphical system that used onscreen blocks with a computer mouse. Specifically, visitors (and especially kids) were more likely to try the exhibit with the tangible blocks than with a mouse. One possible explanation is that the source cultural form was more recognizable in the tangible system than in the graphical system. The most salient aspect of the graphical system might have been the computer mouse and monitor—an entirely different (and more polymorphic) form with different sets of associated resources (including emotional resources). The associated social activities were different as well. The mouse-based exhibit tended to result in a more parent-driven activity, while the tangible exhibit tended to be more child-driven, meaning that children were more active in constructing various programs while parents took on more of a supporting role [9]. As Dourish explains, "a child playing with blocks engages with them in quite different ways than we could provide in a screen-based virtual equivalent; so tangible computing is exploring how to get the computer 'out of the way' and provide people with with a much more direct—tangible—experience" [4] (p.16).

EXAMPLE 2: TABLETOP MUSEUM EXHIBIT

The second example, also from an informal learning setting, involves the use of a multi-touch tabletop in a natural history museum. The activity presented on the tabletop is a multi-level game designed to help museum visitors understand concepts of evolution and phylogenetic trees (Figure 2) [10]. Relevant to this example are the micro-practices surrounding video game play. From research in the Learning Sciences there is evidence that kids engage in rich sets of social activities while playing video games at home [28, 32]. These include a variety of self-organized *learning arrangements* such as mentoring, intent observation, and inner and outer circles of play [32]. Kids are also effectively able to coordinate a variety of quantitative representations common to video games to make predictions and organize their actions around those predictions [28].

Based on this research, there is reason to believe that if kids perceive the tabletop activity as a video game, then many of the associated resources of video game play should become accessible, even though the context is different (a natural history museum rather than a living room). Our analysis of children and families using the exhibit in a museum revealed that families employed a variety of game-like activities (such as play-by-play narration, coaching, and turn taking) to facilitate not only individual engagement, but also group engagement as well.

Notably the social resources that we observed didn't always resemble what might be thought of as "positive" collaboration. For example, two brothers resorted to physically hitting one another on the arm in a dispute over whose turn was next. Despite this conflict, both boys stayed involved in the activity, even without parental intervention or oversight. The *conflict* in this case might have been a well-rehearsed routine that occurs when the two boys play together at home—almost a form of ritualized negotiation to stay involved in the activity. See [6] for another example of surprisingly useful conflict.

Figure 3. A tabletop museum exhibit on evolution in which visitors engage in a multi-level puzzle game.

What is less conclusive from our observations is whether or not the exhibit actually helps people learn—or at least learn about evolution and phylogenetic trees. In other words, while focused engagement is probably necessary for learning, it's not necessarily sufficient in this case. And, the micro-practices of game play, while effective at helping kids learn *how* to play and win games, may not help them learn about the target concepts intended by the designers.

In this respect the role of the parents was interesting. On the one hand, many parents and adult chaperones seemed to discourage children from interacting with the table, making statements like, "we're not here to do that." In these cases, they seemed to perceive the tabletop as a video game, and, as such, an inappropriate activity for a trip to the natural history museum where there are many authentic artifacts on display that can't be seen anywhere else. On the other hand, other parents seemed to perceive the activity as more of an interactive museum exhibit designed for learning rather than a video game. This often led to exchanges between parents and children in which the goals and meaning of the activity were negotiated over time, leading to an activity that was not quite a video game and not quite a traditional interactive museum exhibit either, but something that had combined aspects of both. In this case, having visitors interpret the cultural form of the exhibit installation in slightly different ways might have been valuable to the overall experience.

EXAMPLE 3: GHOST HUNTERS

There are times when the goal of interaction design is to bring about change in culture itself. A good example of this is in the current trend to develop eco-feedback technology [7] to help promote sustainable behavior. The challenge is that the consumption of natural resources such as gas, electricity, and water is largely invisible due to the nature of modern infrastructures—out of sight and out of mind. As a result people have poor understandings of the magnitude and impact of their own consumption. From one perspective, the goal of this community is to bring about behavior change through feedback and reinforcement, an approach that emphasizes change at the level of the individual. However, growing attention on the interplay between social practices and feedback technology (e.g. [33]) has enlarged the unit of analysis to consider families and communities as well as individuals.

In this vein, we developed an interactive system called *Ghost Hunters* designed to engage parents and children in informal learning activities in which they seek out hidden sources of energy consumption in their homes. Our system combines an electro-magnetic field (EMF) detector with a mobile tablet computer. Bringing the Ghost Hunter device within range of an electrical current activates the detector. Families can then use an app on the tablet computer to keep track of the sources of energy consumption that they have discovered so far (Figure 4). For example, bringing the device within a few inches of a microwave oven on standby will make it vibrate and beep. However, the same microwave will activate our system from several feet away while heating up food.

We deliberately created this design to evoke cultural forms of search games like *hide-and-seek* and *I-spy-with-my-little-eye*. We knew that we wanted to involve parents and children together in exploring the home, and search games seemed like a good fit for the types of activities we were targeting—one in which kids search in odd places (e.g. behind couches and so on) to find hidden things. In this case the hidden things are sources of energy consumption.

However, the cultural forms in this example are different from the previous examples in two important ways. First, unlike forms involving jigsaw puzzles and jump ropes, games like hide-and-seek don't typically need physical artifacts. Only the players themselves (and of course places to hide) are necessary. A second related difference is that activities aren't tied to a specific location. Players are free (and even compelled) to explore their wider surroundings. Given these differences, a key question is whether or not we could create a minimal design that would nonetheless suggest particular forms of social engagement. In other words, the device itself is not particularly evocative, but we hoped that its manner of use in context would suggest familiar forms of social engagement.

An evaluation with seven families revealed a variety of ways in which parents supported their children's learning about energy consumption. This included physical support (such as lifting a child up to a light on the ceiling), offering hints and tips, and asking leading questions. These types of activities are reminiscent of search games like hide-and-seek, but more work needs to be done to fully understand whether and how the design evoked specific cultural forms. However, when we asked participants to characterize the activity after it was over, some mentioned things like "hide-and-go-electrical", "treasure hunt", and "electricity hunt". Our design seemed successful in helping families find unexpected sources of electricity use, including so-called energy vampires—devices that consume electricity on standby mode. However, it was less effective in getting families to pay attention to relative consumption (by comparing across appliances) or in attending to the units of consumption (kilowatt hours). This might have been related to the forms that we evoked—activities that encourage discovery of hidden things but not their comparison. Future work would involve thinking about cultural forms that imply

Figure 4. Seeking out sources of electricity consumption using Ghost Hunters.

the comparison of objects or quantities and attempting to integrate those forms into the Ghost Hunter design.

TOWARD A DESIGN PROCESS

It's clear that tangible interaction designers intuitively incorporate cultural forms into their creations all the time, even if they don't plan it that way from the outset. As a case in point, the first two examples in this paper were not created with cultural forms in mind. It was only in retrospect that the role of cultural forms in shaping the interaction around the designs became apparent. However, the inspiration for the third example (Ghost Hunters) came from deliberately thinking about the kinds of social activities that we wanted to promote. This was followed by a brainstorming session in which we considered the types of cultural forms that might or might not produce the outcomes we were looking for.

Of course, not all interactive systems can or should be designed to evoke cultural forms, but this approach can be valuable in situations where cueing certain forms social interaction is essential to the success of the design. To summarize the design approach: Start by considering the forms of social interaction that will contribute to the success of an interactive system. Who should be involved? What roles should they play? Next, think about the kinds of cultural forms that might bring about the desired patterns of social activity. How accessible and appealing are the various forms to the target audience? Formative testing that consciously samples a diverse population might be useful in answering these questions. Finally, think about the fidelity of designed forms to their corresponding source forms. Fidelity to source the form can have a large impact on the appeal of an interface to different segments of the target audience. Low fidelity forms may not be recognized as instances their source forms, thus missing out on potentially valuable practice-linked resources. In this respect, tangible systems have a clear advantage over their graphical counterparts. Through the use of physical and social embodiment tangible systems have greater flexibility to remain faithful to source forms while incorporating interactive media.

LIMITATIONS

While the use of cultural forms can help shape social activity around an interactive system, this approach shares many of the limitations of affordance and metaphor in interaction design. While cultural forms can cue social activity, the results may or may not match desired outcomes exactly. For example, hide-and-seek games are great for uncovering hidden sources of consumption, but not so effective for getting families to compare consumption across different devices and appliances. Cultural forms are also culturally specific and open to interpretation. What works in one setting with one group of people may not be successful in a different context. Likewise, people bring into an activity their own goals and expectations that may or may not align with the designers' goals. In addition, in many cases there are no obvious or appropriate cultural forms to support the desired activity. The good news, of course, is that cultural forms are everywhere, and their use involves a wide array of activities. The bad news is that much of what we hope to accomplish in tangible interaction is novel and goes beyond what we can do with existing tools and technologies. Finally, while cultural forms might be good for increasingly the learnability of a system, they don't necessarily help improve usability in the long-term.

CONCLUSION

In this paper I have proposed an approach to tangible interaction design that looks beyond physical analogies and universal sensorimotor experiences. Specifically, I have argued that designers can purposefully evoke *cultural forms* as a means to activate existing patterns of social activity along with associated cognitive, physical, and emotional resources. This approach to design was inspired by the notion of social and cultural *funds of knowledge* [8, 18] and by Saxe's *form-function shift* framework [29, 30]. Through three examples I have demonstrated how this approach might look in action.

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