A Sustainable Design Fiction: Green Practices

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In this article, we argue that an approach informed by practice theory coupled with design fiction provides useful insights into the role of interaction design with respect to environmental sustainability. We argue that a practice-oriented approach can help interaction designers step away from models of individual behavior and studies of artifacts towards seeing sustainable behaviors as part of multidimensional and interrelated practices and practice elements. We analyze two previously conducted studies. The first study of everyday repair focuses on how people repair their broken objects. The second study of green-DIY examines how green enthusiasts facilitate their practices of making sustainable DIY (do-it-yourself) projects. We describe the practices of everyday repairers and green enthusiasts in terms of materials, competences, and meanings, and the interrelations among those elements, using the framework of Shove et al. [2012]. We argue that understanding the dynamics of practice and their unique configurations is a starting point to redefine the roles of sustainable interaction design (SID). We propose that designers design towards resources and tools in ways that reflect on the challenges of intelligibility of their design interventions in practices. In addition to considering SID in the light of practice theories, we reveal how design fictions are readily incorporated into green practices in ways that transform those practices and hold implications for transformations of design as well. We bring forward opportunities for designers to co-design with DIY enthusiasts, targeted as practitioners in their own right, designing toward or within a design fiction. As a result, we conclude with the possibility for sustainable interaction designers to become practice-oriented designers who design with transparent open strategies and accessible materials and competences.

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1. INTRODUCTION

This article explores how sustainable interaction design (SID) can be informed by viewing sustainability within a framework of social practices. We take this tact in contrast to the tradition of HCI that is to focus on individual behaviors as the object of study and intervention. Our approach is also in contrast to the tradition of design that is to focus on the making and production of artifacts and systems as a unit of study and means of intervention. The value of focusing on practice as the unit of study is

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that it provides a holistic view of sustainable behaviors. This type of focus addresses the complexities, interdependencies, and dynamism of the collective and cumulative actions we take. Understanding practices situate competences, materials, and meanings in the geographic, historic, cultural, political and technical contexts in which they take place. We advocate a practice orientation that avoids the underlying assumptions of causality and rational choice behind models of individual behavior that invariably aim to persuade people or make them compliant through rational decision-making.

For many of us, these models of individual behavior are too brittle and reduce the complexity of the issues, interactions, and effects. As designers and design researchers, we hold certain unease with the assumptions of causality and rational choice behind designing for sustainability or interaction in general. However, in understanding practice we have to accept the emergent qualities of practices that render prescriptive and instrumental views of the impact of technology and design as limited. This is not to say that design, policies, or other interventions cannot productively influence actions of practice, culture, and social systems but these come with limitations. Paraphrasing Shove et al. [2012] from the perspective of a designer, interventions operate in relation to other factors and other interventions that are either in place or in operation independent of whatever aims designers may have. The outcomes of interventions in the dynamics and "moving targets" of practice are highly unpredictable. The vital influences of the conditions of practice are at a governmental and policy scale that is not typically the purview of interaction designers and HCI practitioners [Shove et al. 2012, p. 162]. Nevertheless, designers with stated goals (like sustainability) need to continue to pursue interventions in practices. Understanding the dynamics and elements of practice allows designers to reflect more specifically on how design actions enable or constrain practices.

Practice can be viewed as embodied patterns of behaviors and ways of understanding, knowing how, and desiring. In our study, we draw from Reckwitz, Schatzki, Bourdieu, Latour, and Shove et al. for grounding our own position on practice, however we mainly rely on the theoretical work of Elizabeth Shove, Mika Pantzar and Matt Watson [Shove et al. 2012], more specifically on their framework on the dynamics of social practice that centers on the elements of competences, materials, and meanings in practices.

In addition to considering SID in the light of practice theories, we offer in this article a designers' response to practice theory in the form of design fictions. Design fictions take the form of narratives, prototypes, and concepts that project a design concept represented in a future situated action. We propose that design fictions can be readily incorporated into practices in ways that transform those practices and hold implications for transformations of design as well. We see design fictions as a designerly response to social practices in that rather than focus on social analysis and policies, designers engage in a material reflection that is based in making and doing, where scenarios, prototypes, sketches, and illustrations are materials of thought for design. Designers build corpuses of exemplars that are not prescriptions but actualized potentials that present opportunities and limits for design. We suggest design fictions as a viable form of design actions informed by practice theory.

We devote the first part of our article to discussing, and hence bringing together, SID, theories of practice, and design fictions. With these concepts in hand and Shove et al.'s [2012] practice framework we illustrate the value of a practice-oriented approach to sustainable actions with a thematic analysis of two different studies we conducted on everyday repair and green do-it-yourself (DIY). We emphasize the linkages among elements of practice in everyday repair and green-DIY. The aim of discussing these examples is to demonstrate how practice theory can help guide interventions and implications for SID.

Our article sets out to respond to two questions: (1) what are the practice elements of green-DIY and everyday repair that inform interaction design and form the basis for a design fiction approach? (2) what is the role of interaction design and design fictions with sustainable practices like green-DIY and everyday repair?

We devote the latter sections of our article to exploring how interaction design can enable sustainable practices in terms of existing routines and actions. We extend our discussion of practice theory to convey the dynamics of practice and how they transform. With the dynamics of a social practice as a theoretical backdrop we explore the role of interaction design to enable practices through reconsidering the design of tools and materials. We also investigate the intersection between design fictions and green-DIY and the implications this holds for sustainable practices and SID.

2. SUSTAINABLE INTERACTION DESIGN, PRACTICE THEORIES AND DESIGN FICTION

In this section, we present related literature in the field of SID that primarily shows a reliance on models of individual behavior and /or a study of artifacts. We then give an overview of practice theory highlighting useful concepts that will frame the descriptions of our studies and present the framework we will use for our analysis. We provide literature that bridges the fields of social practice and HCI, as well as social practice and SID. Finally, we describe the concept of design fictions and how we can leverage this idea to develop observations of practice into implications for interaction design and the dynamics of practices. This lays the foundation for our argument to couple practice theory with design fiction in order to uncover new approaches to sustainable interaction design.

2.1. Sustainable Interaction Design Literature Review

SID and sustainable HCI have rapidly evolved since articulated by Eli Blevis [2007]. We can characterize the evolution as a widening of attention that begins with individual behaviors and rational decision-making. For example, DiSalvo et al.'s [2010] analysis of the field notes that persuasion as a topic accounted for close to half of the reviewed literature. The research on persuasion in sustainable HCI generally builds on psychological research focusing on the understanding of human behavior [Fogg 2003]. The rationale behind most persuasive technologies, such as eco-feedback technologies, is that people lack awareness and understanding of how their behaviors have an impact on the environment. By providing information, designers believe they can influence the psychological and behavioral factors motivating everyday decisions [Pierce et al. 2008]. Persuasive technology and eco-feedback technology draw on decades of research in human psychology, behavioral change, persuasion, and environmental psychology [Fogg 2003 and Froehlich et al. 2010] making it clear that for many in HCI and SID sustainability is a product of the individual mind.

Yet Pierce et al. [2010] argue that behaviors are not always the result of attitudes or intentions and therefore we need to observe other aspects of unsustainable behavior. Another approach to SID has been to shift from studying the cognitive aspects of behaviors, to studying specific objects and actions as the source of sustainable or unsustainable behaviors. Huang and Truong [2008] studied mobile phones to understand the reasons for acquiring, discarding, or replacing a phone and reveal opportunities for SID of mobile phones. Odom et al. [2009] used a personal inventory method to explore why people preserve or discard things in a SID context. The authors describe factors influencing the strength of attachment between individuals and objects such as function, material qualities, and perceived durability, as well as relationship properties like histories and engagement.

Additionally, researchers have focused on understanding particular routines related to sustainability and HCI. Studies of family routines and design-in-use practices

[Wakkary and Tanenbaum 2009], practices of reacquisition and dispossession of artifacts [Pierce and Paulos 2011], practices of repair [Maestri and Wakkary 2011] and normal and wasteful practices related to specific devices in the home [Pierce et al. 2010] aim to show how sustainability (and unsustainability) is inherent in everyday actions and routines. Woodruff et al. [2008] conducted a study of households who were living a green lifestyle by making important transformations to their homes and behaviors. The authors describe motivations, practices, and experiences of individuals and conclude that sustainable behaviors and decisions are mainly a matter of personal choices (needs to stem from the individual) as well as circumstances and surroundings (the context needs to serve as a complement to personal motivations). Finally, Kim and Paulos [2011] developed a design reuse vocabulary based on the observation of e-waste that individuals kept at home. Their goal was to find ways to prolong the life of electronic products by supporting their creative reuse.

Related to sustainability and to our studies is literature on particular communities that engage in acts and practices of making, that is, enthusiasts or DIY. Enthusiasts have been the focus of research in recent years, particularly because they challenge the current consumption model by using a creative and rebellious DIY approach rather than buying premade goods. Kuznetsov and Paulos [2010] present an analysis of DIY practices online that supports these communities. The authors argue that DIY is gaining in importance because of the accessibility and affordability of tools, and because of the appearance of new tools enabling sharing, particularly in the case of online tools. Other studies have investigated DIY communities such as Ikea hackers [Rosner and Bean 2009] and knitter and gardeners [Goodman and Rosner 2011] and describe the relationships among creative practices and emergent information technology and online tools. Additionally, Torrey et al. [2009] conducted a study on how crafters document and search for knowledge about crafts on the Internet. Their findings show that participants use online tools to seek information about techniques as well as inspiration for projects.

In this article, we propose to broaden our observations further than models of individual behavior and to observe sustainable behavior as a practice. Our practice-oriented approach contrasts the behaviorist approach of eco-feedback and persuasive technologies and extends the object and technology oriented studies with additional focus on everyday and DIY creativity.

2.2. Theories of Practice and Their Role in Our Studies

2.2.1. Key Concepts in Practice Theory. In this section we give an overview of key practice theory concepts that serve as theoretical foundations for our article. Practice theory conceptualizes human actions and the ways people conduct their everyday lives by focusing on *practice*. Primarily we discuss concepts that draw from Reckwitz, Schatzki, Bourdieu, Latour, and Shove et al. for grounding our own position on practice. We also look at the role of technology and design in configuring practices as an important consideration in designing toward sustainable practices as a point of departure, we give a theoretical overview of what social practice entails and how this has framed our analysis of green enthusiasts and everyday repairers.

We begin our discussion with Andreas Reckwitz [2002a, 2002b, 2003], a cultural theorist whose idealized theory of practice aims to synthesize the common contributions of Bourdieu, Giddens, Foucault, Garfinkel, Latour, Taylor, and Schatzki [Reckwitz 2002a]. In Reckwitz, practice theory, while not a systematic theory, can be seen as an emerging *social-theoretical vocabulary* that offers alternative insights into social actions and represents an embodied formulation of knowing. According to Reckwitz [2002a, p. 249], practice is:

> a routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotions and motivational knowledge.

Practice as such constitutes our everyday lives from the way we cook, work, consume, inquire, maintain our health and home, and so on without limit. Individuals act as carriers of practices (multiple and different practices that may or may not coordinate together), which embody "patterns of bodily behaviour" and "routinized ways of understanding, knowing how and desiring" [Reckwitz 2002b, p. 250]. Among the key shared precepts of practice theory is that knowing is embodied [Reckwitz 2002a] and that doing in practice requires artifacts (see Reckwitz [2002a, p. 51, 2002b, p. 207]). With these concepts in hand, we approach both everyday repair and green-DIY as practices whose material realities can be described by the embodied competences demonstrated, the materials employed, and the underlying meanings.

Further, practice theory provides an alternative to the concepts of purposeful driven individuals (homo economicus) or normalizing behaviors (homo sociologicus) that underpin classical social theories [Reckwitz 2002a, p. 244]. These approaches construct actions as utilitarian choices or the following of accepted rules, at the expense of "the implicit, tacit, or unconscious layer of knowledge" that structures practice [Reckwitz 2002a, p. 246]. These conventional notions create models of rational decisions or social order in cases where they may not exist, obscuring what Reckwitz sees as "a 'shared knowledge' which enables a socially shared way of ascribing meaning to the world" [Reckwitz 2002a, p. 246]. Practice is social, encompasses actions that appear in different contexts, locales, points in time, and is carried by different individuals. Hence, in our approach we view sustainable actions not as rational choices or normalizing rules to follow but as embodied and social practices that emerge uniquely in everyday repair and green-DIY.

Reckwitz's understanding of practice draws on the work of the philosopher Theodore Schatzki. Schatzki's aim is to develop a systematic theory that looks at practice as a central phenomenon for understanding the social constitution of individuals, a phenomenon embodied in the routinized actions of the body [Schatzki 1996; Schatzki et al. 2001]. Schatzki champions practice as the site in which understanding of social life is structured and intelligibility of social life (i.e., making sense of the world) is expressed. In Schatzki, the skilled body is where activities of the mind, body, individual, and society meet [Postill 2010]. Practice is a coordinated entity in which there is a spatiotemporal unfolding of bodily activities or a carrying out of certain doings and sayings in a particular context. Schatzki views practice as a performance, a process of doing and repeating in which practice-as-entity is sustained and changed [Schatzki 1996].

The critical writings of the sociologist Pierre Bourdieu on practice [Bourdieu 1977] precede Schatzki and Reckwitz and in large part helped introduce practice into the discussion on social and cultural theories. He is among the first generation of practice theorists [Postill 2010] in arguing that the social resides in embodied actions of practice and not structures of models or language. Yet Bourdieu's writings were less influential on developing practice theories in that he referred to practice in more general terms and was focused on his theoretical conceptualization of habitus [Shove et al. 2012], which is the internalization of the material conditions of existence that are characteristic of a particular agent, i.e. history, traditions, and customs [Bourdieu 1977]. Bourdieu describes habitus as both an enduring and dynamic system that generates and structures practice.

Reckwitz applauds practice theorists for shifting sociology from "subjects" and "texts" to "practices" as the fundamental conceptualization of the social [Reckwitz 2002b, p. 210]. Yet he remarks on the general absence of the discussion of things: "If

Schatzki emphasizes that practices are a nexus of 'doings and sayings' and that they are not identical with the constellations of intersubjectivity, then these doings must also necessarily be doings with things" [Reckwitz 2002b, p. 211–12]. As a means to insert the discussion of things in practice theory, Reckwitz [2002b, p. 211–12] considers Bruno Latour's position:

> Here we can integrate–at least to a certain extent–Latour's position in Schatzki's: not only human beings participate in practices, but also non-human artefacts form components of practices. The things handled in a social practice must be treated as necessary components for a practice to be "practiced."

From the perspective of material studies, Shove et al. echo Reckwitz in viewing the importance to understand objects and materials with respect to theories of practice [Shove et al. 2007]. For example, their analysis of DIY home renovations focuses on doing and highlights the interaction among tools, materials, and the competences of the maker. The authors explore the distributed competence between the object (tool) and the human. Latour's concept of hybridity suggests that in a human-nonhuman hybrid [Latour 1987] the competence is divided between the embodied knowledge (in the human) and the embedded knowledge (in the object and materials on which human acts). In this sense competences of practice are configured by the design of the tools. Building in part on Latour's ideas infused with practice theories, the goal of Shove et al. is to show how artifacts and materials are implicated in the development, persistence, and disappearance of patterns and practices in everyday life. They state that this is based on an active integration of materials and objects, conventions, and forms of competence. Shove et al. [2012] present a framework to analyze the dynamic aspects of social practices. This framework refines positions presented in previous writings [Shove 2003; Shove et al. 2007], offering a simplified and targeted use of practice theory with additional selective use of notions from within science and technology studies (STS).

Inspired by Reckwitz and his aforementioned notion of practices consisting of interdependent elements, Shove et al. [2012] form their own more simplified understanding of practice as a composition of three elements: material, competence, and meaning.

Materials: "[include] things, technologies, tangible physical entities, and the stuff of which objects are made,"
Competences: "encompass skill[s], know-how and technique[s]," and
Meanings: "include symbolic meanings, ideas and aspirations [Shove et al. 2012, p. 14]."

Based on the notion of Reckwitz, Shove et al. [2012] describe people as carriers of practices, which allows them to analyze patterns from a different point of view, looking at the recruitment and defection of practitioners. Moreover, the authors use the distinction of practice-as-entity and practice-as-performance articulated by Schatzki (presented earlier). The latter can be understood as a the "regular enactment" of practices [Warde 2005, p. 134] and the former as "a recognizable conjunction of elements, consequently figuring as an entity which can be spoken about and more importantly drawn upon as a set of resources" [Shove et al. 2012, p. 7]. More specifically this means a practice-as-performance involves an "active integration of elements (materials, meanings, competences)" and "practice-as-entity are constituted through such integrations" [Shove et al. 2012, p. 120]. With those two conditions Shove et al. analyze practices from different angles, conceptually take them apart and analyze their elements.

With their simplified framework, Shove et al. are able to detect and describe patterns of practices and their elements, and thereby define dynamic aspects of social practices [Shove et al. 2012, p. 120].

> Practices change when new elements are introduced or when existing elements are combined in new ways. Elements of meaning, materiality and competence are themselves outcomes of practice. Although they are generated and changed through moments of enactment, elements—being part of several practices at once—have somewhat independent lives of their own. If practices are to survive they need to capture and retain practitioners [. . .] willing and able to keep them alive. Relations between practices take somewhat different forms—some collaborative, some competitive, some weak, some strong. Whatever form they take, such relations matter for trajectories of the elements and individual practices of which composite bundles and complexes of practice are made. Finally, the connections involved, between elements and practices and between one practice and another, are maintained and reproduced through intersecting circuits of reproduction that have dynamic qualities of their own.

2.2.2. Our Approach to Practice Theory. In this article, we draw on the framework used by Shove et al. [2012] and analyze practices-as-entities looking at materials, competences, and meanings in everyday repair and green-DIY. Compared to other approaches by social theorists, this framework presents a simplified notion of practice. This makes the conceptualization and analysis of practices and their elements more feasible.

The distinction of three elements of practice is helpful for looking at innovative processes that can lead to informative results for designers. Of interest for designers and researchers in HCI and design, Shove et al.'s [2012] framework includes materiality as a dimension of practice, which was often left aside in other frameworks (except Reckwitz and Latour), as stated above. Physical and digital materials are the starting point for the realization of any design project and particular attention needs to be directed towards materiality as part of practices of design. The aspect of competence is also highly important, mostly in relation to the practice of makers, everyday designers, and DIY enthusiasts because of the wide range of competences between beginners and experts within these communities. Finally, meaning can help frame and evaluate the aspirations and motivations behind practices of everyday repair and green-DIY. As a way to analyze and gain an understanding of everyday sustainable practices, we believe that the combination of material, competence, and meaning can help us gain valuable insights for interaction design.

Additionally, the framework of Shove et al. [2012] affords the possibility to look at how practices and their elements change and how this can lead to transformation and innovation in practices. We take up the discussion of transformations of practices later in this article (see Section 5).

2.3. Design Fiction

We introduce design fiction as a bridge between design, green-DIY, everyday repair and the social/cultural theories of practice. Design fictions relate to representations of the future from science fiction to design scenarios that detail "people, practice and technology" [Bell and Dourish 2007, p. 133]. Discussions on technological futures have been well established within Science and Technology Studies (STS) [Brown et al. 2000; Sturken et al. 2004; Retzinger 2008], yet these discussions are new to interaction design and sustainable design, specifically the idea of 'design fiction'. Since design fiction is a relatively new term and there is no firm consensus on its use, we purposely take a broad look incorporating approaches from cultural critique to design envisioning. In this section, we provide an overview of the diverse discussions related to design fictions and subsequently point to how we frame design fictions as relevant to the discussion of sustainable practices.

2.3.1. What is Design Fiction?. The earliest use of the term design fiction appears to be in a presentation given by Julian Bleecker in 2008 at the Engage Design Conference.[1]

[1]http://www.slideshare.net/bleeckerj/design-fiction-design-engaged-julian-bleecker-presentation-638179.

That in turn references a paper by Paul Dourish and Genevieve Bell entitled Resistance is Futile: Reading Science Fiction Alongside Ubiquitous Computing [Dourish and Bell 2013]. The talk became a digital essay [Bleecker 2009a] and blog entry [Bleecker 2009b]. Bleecker [2009b] sees in the idea of science fiction a genre-methodology for design.

> Design Fiction is making things that tell stories. It's like science-fiction in that the stories bring into focus certain matters-of-concern, such as how life is lived, questioning how technology is used and its implications, speculating about the course of events; all of the unique abilities of science-fiction to incite imagination-filling conversations about alternative futures. It's about reading P.K. Dick as a systems administrator, or Bruce Sterling as a software design manual.

Dourish and Bell [2013] look to read the technological reality of ubiquitous computing against a body of fiction, in particular science fiction. The authors acknowledge that science fiction holds the ability to not only presage technological futures but to shape them through their effect on the collective imagination. For example the form and function of mobile phones could be said to have internalized past fictions like Star Trek communicators. Further, science fiction provides a representation of a practice in which technical and material developments will be understood. It is not only that science fiction stories offer imaginary prototypes of things to be but also that science fiction creates prototype environments in which things are discussed, understood, and used within a context. This embedding of design and technology in people and practices brings to the fore the cultural questions of these futures and the roles of technologies. Dourish and Bell [2013] argue that these cultural issues are inherent in our notions of design and technology. Science fiction reveals our prior cultural commitments before any implementation of design or technology. What emerges in their readings of science fiction is an "imaginative and speculative figuring of a world" in which new things and technologies will inhabit; and the bringing into focus of the "central role of sociological and cultural considerations" that are often obscured in our techno-centric reasoning of actual technologies [Dourish and Bell 2013].

Dourish and Bell [2013] show how science fiction can be read in critical fashion to delineate the interdependencies of fiction, design, and technology in shaping future technologies. Design fictions inhabit multiple forms of narrative from science fiction to technology research visions like Mark Weiser's famous *Scientific American* article on ubicomp [1991] to scenarios and prototypes in design.

Similar to Dourish and Bell, Reeves [2012] sees design fictions as texts to be read and unpacked. Reeves extends design fictions beyond science fiction texts to include "future scenarios described in papers and books, promotional research videos, research 'vision statements' and proposals, statements of justifications in research papers, and of course the construction and deployment of technological artifacts" [Reeves 2012, p. 1573]. Reeves refers to these as *envisionings*. In our case we include envisioning within the concept of design fictions. Envisionings are "future-oriented aspect of technology design which mixes fictions, forecasts, extrapolations or projections into a societal visions for technological progress" [Reeves 2012, p. 1573].

Reeves provides a broad critique of envisionings in ubiquitous computing and virtual reality. He settles in on the problematic teleological nature of most envisionments; that is the underlying technical determinism that sweeps most cultural and technical issues aside in the name of progress. He argues that a way through this is to disentangle the aspects of fiction from the less productive qualities of forecasting and extrapolations. Forecasting is "a morally accountable activity" that often becomes a "broken promise" [Reeves 2012, p. 1578] failing to understand the *mess* of ubicomp or any future technology [Dourish and Bell 2011]. Extrapolations bring with them our

current assumptions of technology and progress. Forecasting and extrapolating enable the teleological conceits that lead to determinist views of technology and society.

Reeves [2012, p. 1580] suggest an alternative reading of envisioning that is more fiction than prediction.

> [E]nvisioning should more often be treated explicitly [as] fiction. Fiction is a powerful, creative and playful way to reason about what we are to do in the future. Fiction guards against the teleological tendencies of forecasting, against explaining away 'bad' predictions and lauding 'accurate' ones. As a creative endeavour, fiction opens up possibilities that forecast tend to shut down. Fiction transforms the assumptions of envisioning that forecasting employs—that there are 'enabling' technologies for the future, that we can project from existing capabilities, that we can rely on proliferation of technology, or that we can imagine future societal situations—and instead uses those assumptions to drive design thinking about the present.

Reading envisionings as fictions opens it to broader critical interpretations that diversify the focus beyond the technology itself to a wider reading of the situated nature of technologies and people. Fiction also extends the role of envisioning for designers in the use of design fictions as a design method. Reeves specifically cites Bleecker's method of design fiction that sets out the goals of not only reading but generating design fictions that express multiple futures and by that let go or challenge assumptions about the direction and breadth of progress. Bleecker and Reeves see in design fictions a design method that engages assumptions of the future as a means to derive critical understandings of the present. Reeves [2012, p. 1580] writes:

> Twisting envisionings in this way means embracing the production of principles for design rather than designs from forecasts of use or situation[. . .]. Thus, principles expressed in designs are questions for future use. These principles are explicitly tied to the context in which they are produced and not contingent upon a forecast future. They promote the acceptance of *uncertainty* as a valid (and animating) feature of research work, and *trial and error* as a way of continually recalibrating and refining those principles.

Similarly, Shove et al. [2007] use the term *material narratives* to describe prospective writings about new materials. The authors state the critical aspect of those narratives in the development, production and adoption of innovative materials. For example, they cite Yarsley and Couzen, two applied chemists, authors of the classic text Plastics that describes the life of a plastic man living in a world where everything is made of colorful, bright, clean, and shiny plastic. The authors imagined "a world free from moth and rust and full of colour" [Yarsley and Couzens 1941, p. 57] as well as "a world in which man, like a magician makes what he wants for almost every need, out of what is beneath him and around him: coal, water, and air" [Yarsley and Couzens, p. 68]. They argue that storytelling can help articulate expectations, which can eventually be embodied, rejected or later changed [Shove et al. 2007, p. 98].

2.3.2. Our Approach to Design Fiction. We can summarize our understanding of design fiction as follows.

—Design fictions can be read or produced in various narrative forms from science fiction to research proposals to prototypes.
—Design fictions manifest the relationships among people, practice, and technology that inherently reveal practices and cultural assumptions embedded in the future design.
—Design fictions can be read or produced as fictions that are powerful, creative, and playful representing diverse, uncertain, and experimental futures that reflect on the present.

—Design fictions produce design principles rooted in the context in which the design fiction was produced.

Science fiction writer Bruce Sterling [2009] bemoans how badly designed objects of the future are in science fiction. He argues that science fiction authors lack the experience of the material practice of making things. This echoes Reckwitz's point that the relationship between artifacts and the practices is not arbitrary [Reckwitz 2002b, p. 212].

> [T]he relationship between human agents and non-human things in the network of practice is a relationship of practical understanding. Simultaneously, in such a relationship the artefacts do not allow any arbitrary practical use and understanding, they are not suitable for arbitrary practices.

Sterling points out that the embodied imaginary constraints are different between designing and writing. The embodiment of writing is the platform of publishing, typing, and print language. Sterling feels that in order to learn to write design fiction well an author needs to trade the imaginary constraints of writing for the imaginary constraints (and opportunities) of design [Sterling 2009].

In examining the relationship among practice, design fictions, and DIY we can now look at how design fictions play a role in green-DIY and everyday practices. In our discussion section (see Section 6 Design Fictions: Reimagining Practices) we will address how green-DIY enthusiasts make new artifacts from both reading and producing design fictions. We also show how the idea of audience can be disentangled within design fictions that lead to interesting innovations and opportunities. We will explore how the element of meaning in a practice like green-DIY mobilizes the elements of competence and material to readily realize design fictions. This leveraging of present-day practices reimagines the means of producing artifacts that holds implications for interaction design. And so, we also look at how this relationship to design can transform practices and points to a different type of designer.

3. PRACTICE-ORIENTED SUSTAINABLE INTERACTION DESIGN

In the sections above, we introduced SID, theories of practice, and lastly design fiction with an eye toward how these ideas inform a practice-oriented approach to interaction design and in the case of our study, implicit and explicit sustainability. In the following sections, we briefly present related literature in HCI and SID that use practice theories, describe the goals of this article, introduce our two illustrative studies that serve as cases that point toward a practice-oriented SID, and provide a roadmap for how we make our argument.

3.1. Social Practices in HCI and SID

Theories of practice have been used sporadically in HCI in different contexts. For example, Wulf et al. [2011] propose to use the perspective of practice theory as a way to focus on transformative and innovative aspects of information and communications technology artifacts in computer-supported cooperative work research. Other examples include using practice theory as a way to understand discursive relationships between people and artifacts in the context of documentary practice [Scifleet and Williams 2009] and creating tools to encourage design stakeholders to use practices as units of analysis in the design process [Cabrera et al. 2008]. In these examples, practice theory is used either as a way to broaden a perspective on a situation or to embrace the evolving and changing nature of practices.

Practice theory has also been used in works of SID. Pierce et al. [2011] propose to use descriptions of everyday practices as a way to rethink how HCI should address and frame concerns and issues of sustainability. Strengers [2011] challenges the rationale

behind eco-feedback technology, which supposes that householders are 'micro-resource managers' [Strengers 2011, p. 2135]. She argues that the consumption of energy and water is not only a question of management, but that it is situated in a social, cultural, and technical system that is dynamically changing.

Our aim in this article is to contribute to the latter research on the applicability of practice theory to SID. We aim to show how we can move beyond improving and refining interaction design outcomes through using theories of practice as analytical tools. Rather, by coupling practice theory with design fictions, we aim to show how it can be employed generatively to create a more open and participatory interaction design that leads to a degree of radical rethinking of the role of sustainable interaction designers and the nature of interaction design itself.

3.2. Goals of the Article

The promises of practice-oriented design are multifold. One is that we design to sustainable practices that are in place rather than intervene to change behaviors or alter routines. Acknowledging those for whom we design as practitioners or carriers of practice changes the dynamic, imposing a more synthetic approach. This approach acknowledges a coordinated set of competences, materials, and meanings from which the needs or opportunities for design reside. Following Shove et al.'s [2012] research we see how the design of things configures practices. In this sense we can design to configure practices that *lean* toward sustainability, and reconsider the practice of interaction design as a means to better enable sustainability. Last, when practices are motivated by elements like meaning, this implies potential changes in both practices and interaction design.

The promises of design fictions are also multifold. Design fictions operate in a multiplicity of forms from writing to illustration to research proposals to prototypes thus opening up the availability of design thinking to many. Design fictions are synthetic and so manifest the relationships between people, artifacts, and contexts assuming practices and cultures and moreover grounding design principles holistically. Most importantly, design fictions are powerfully creative and playfully open up imaginative thought, actions, and realizations to diversity, experimentalism and uncertainties that reflect as much on the present as figure the future.

3.2.1. Questions and Propositions. Our intent in these studies is to understand these activities as practices and to consider how these inform and can inform envisioning and the implications these together hold for SID. More precisely, we ask two questions and related propositions.

The first question asks: what are the practice elements of green-DIY and everyday repair that inform interaction design and form the basis for a design fiction approach? As a related proposition we assume that practices will be configured uniquely. This implies that designers need more than a generic model or understanding of practice. Specifically, we are looking for configurations of elements that mediate bodily actions and competences with materials, and meanings in unique relationships. We assume these configurations will inform a rethinking of current interaction design approaches and reveal ways in which design fiction as a practice is either emergent or can be leveraged as an approach for interaction design.

Our second question asks: what is the role of interaction design and design fictions with sustainable practices like green-DIY and everyday repair? In our first question we asked about the configurations of practices and the potential for design fictions. Here we assume that a reorientation of interaction design toward practice will reconfigure interaction design itself. On a practical level, we propose that design intervenes in practices at the level of tools and materials rather than artifacts. Further, we see design

fictions as a design response establishing a particular relationship to practices that enables transformations of practice and points to changes in interaction design as well.

3.2.2. Roadmap. After having laid the foundation for our argument in our discussion of related SID research and overviews of theories of practice and design fictions (see Section 2, Sustainable Interaction Design, Practice Theories and Design Fiction), we tackle our research questions in the remainder of the article in three parts. In the first part (see Section 4, Analysis of Two Green Practices: Everyday Repair and Green-DIY), we analyze our two illustrative cases of everyday repair and green-DIY utilizing Shove et al.'s framework as a means to determine the respective elements of practice within these sustainable approaches that can inform interaction design. In the second part (see Section 5, Discussion), we pursue our second research question to determine the role of interaction design to support practices through reconsidering design of tools and materials. We enable this discussion by adding a critical theoretical component from practice theory to convey the dynamics of practice and how they transform (and innovate) over time. The third and last part to our argument (see Section 6, Design Fictions: Reimagining Practices), we draw on the delineated elements of practice and emergent aspects of design fiction in green-DIY to explicitly couple design fiction with theories of practice. We discuss three examples of a design fiction understanding and approach to green-DIY that illustrate how we can reconsider and reshape sustainable interaction design to be more open, engage participation and find new ways to innovate.

3.3. Our Illustrative Cases: Everyday Repair and Green-DIY

In this section, we introduce our two illustrative studies: the practice of everyday repair and the practice of green-DIY. These two studies were designed differently and the data was collected in various ways. We bring the two together in this article as a way to show the range and differences between practices of sustainability. Hence, we do not present a comparative analysis but rather use examples of the most significant observations to provide support for our discussion.

3.3.1. Everyday Repair. The first study, called everyday repair, sought to understand how everyday people, meaning nonspecialized or experts, repair their broken objects. Specifically, we want to understand what motivates people to repair, reuse, repurpose, or simply keep their broken objects, the techniques and processes by which they do this, and what outcomes result from the techniques and processes they employ. This study contributes to existing research of sustainable actions related to the reuse and extension of objects' lifecycles [Blevis 2007; Huang and Truong 2008; Kim and Paulos 2011; Odom et al. 2009; Pierce et al. 2008; Pierce and Paulos 2011].

Our study on everyday repair was comprised of a 3-question survey disseminated via email, asking participants the following questions: have they kept any broken objects and why; have they repaired (or attempted to repair) their objects, and if so, to describe their process; and lastly, have they successfully reused or repurposed their objects as a result of their repair? This questionnaire was distributed to a wide range of individuals from Vancouver and Montreal. Participants ranged between the ages of 20–65 and came from different professions including university students, a lawyer, designers, musicians, teachers, a dental hygienist, and a stay-at-home mom. Over 40 participants submitted responses and approximately 120 objects were submitted as examples of objects that were in various states of being broken and/or repaired. The types of objects submitted were both nondigital and digital in nature, though a large majority of the objects were nondigital. We acknowledge that the limited and short questionnaire sent to participants can be a limitation to the study. In addition, the data collection was done through email, which limits the richness of the data. However, we feel the number of responses received compensates for these drawbacks.

3.3.2. Green-DIY. Our second study aims at understanding the motivations, objects, tools, and skills used by green enthusiasts (individuals who create projects that support a sustainable lifestyle). Kuznetsov and Paulos [2010] define DIY to be "any creation, modification or repair of objects without the aid of paid professionals" [p. 295].

This study builds on previous studies of DIY online communities [Kuznetsov and Paulos 2010; Rosner and Bean 2009; Goodman and Rosner 2011; Torrey et al. 2009], but focuses particularly on Web sites and blogs that are oriented towards sustainable living. We are mostly interested in understanding the underlying practices of green enthusiasts, using *green blogs* as an entryway to observe how people make green projects. In our study of green-DIY, we started by visiting 17 Web sites that supported sustainable practices and projects. The green blogs were found through the snowball effect. We narrowed down our sample with two filters. The first requirement was to present DIY projects in the form of inspiration ideas or tutorials, and the second was to explicitly target environmental sustainability as a main goal. We narrowed the results to 5 Web sites: *Crafting a Green World, Green Upgrader, Instructables, Planet Green*, and *Simple Organic*.

We used posts from these green blogs as our data. We augmented this data with an email questionnaire directed at authors and readers of the blogs, more specifically readers who left comments on posts. We recruited participants from each of the five sites by scanning through their posts. The questionnaires were sent via email to four authors and four readers from each Web site. Participants were asked about their intentions for using the Web sites, their views on environmental sustainability and materials, and about their use of tools and techniques. Moreover, some of the questions targeted the social aspects of using green blogs and the practices of information sharing and networking. We received four responses from authors and six from readers. The low response rate by authors and readers is a limitation of this study, however, we believe that the blog posts themselves are rich enough to inform our analysis. In addition, we acknowledge that our participant selection (online) could create a bias towards the importance of online learning and sharing tools amongst green-DIY enthusiasts.

4. ANALYSIS OF TWO GREEN PRACTICES: EVERYDAY REPAIR AND GREEN-DIY

As mentioned before, we make use of the framework from Shove et al. [2012] for looking at our two studies of green practices. Our examination of these practices aims to answer our first question, what are the practice elements of green-DIY and everyday repair that inform interaction design and form the basis for a design fiction approach? In this framework, practices consist of three interdependent elements: materials, competences, and meanings.

Materials include objects, their tangible physical aspect, technologies, tools, the body, and the stuff objects are made of. In our cases, including the characteristics of materials such as the origin and the intended or appropriated use of it can also be important.

Competences entail skills of the respective practice, as well as know-how and techniques. Meanings are understood as motivational factors behind a practice. They encompass the idea and aspiration of a practice and further aspects that bring significance to the actions in a practice.

In the following sections, we highlight important findings from our analysis of everyday repair and green-DIY, including observations about the elements and their relationships.

4.1. Everyday Repair

In this section, we briefly describe the meanings of the everyday repair practice, since in this case we mainly concentrate on the element of competence and how materials are closely related to the skills and know-how of practitioners.

Fig. 1. Using a hockey stick to replace window stoppers.

4.1.1. Meaning. The repair of an artifact can entail different meanings for practitioners. In general, repair happens mostly in order to change an undesired situation; a broken object. A common motivation across everyday repairers is the necessity of an object; that is, the simple perceived need for an object. A different aspiration is to fulfill personal interest in repairing and keeping an object. Individuals are driven to preserve an object's perceived meaning and beauty. Personal attachment to objects for emotional, sentimental and familial reasons are also part of the motivations people have when repairing.

For everyday repairers, explicit environmental concerns mostly deal with the responsible disposal of broken technological objects. One participant describes it as follows.

> I have a number of old electronic odds and ends that I haven't been able to throw away primarily due to the fact that there isn't an easy place to dispose and recycle old electronics. Call it environmental guilt.

Finally, some everyday repairers are driven into action based on the significant investments they placed in their objects in terms of time and money.

4.1.2. The Relationship of Competences to Materials. Our study of everyday repair reveals an important relationship between practitioners' competences and the materials they utilize. The relationship between the broken materials and the competences everyday repairers have is central to whether a repair will be successful, let alone attempted. The practice of everyday repair encompasses different know-how and techniques. In order to start the process of repair, practitioners imagine and envision solutions that are possible with the techniques they know and the materials they have. They create a new vision for what an object should become and reflect, consciously or unconsciously, on what material attributes are necessary for accomplishing the repair. At the planning level, we see how materials—and the ability to transform them—have an influence on the types of repair that might be carried out. Often individuals come across a material similar to the one they have had in mind for resolving a break and use them based on their original vision. As an example, we refer to a participant who describes his idea of using a piece of wood to replace his broken window stoppers (see Figure 1).

> I knew I was going to use a piece of wood for fixing the window problem and was going to use any piece of wood I could find. I don't know what triggered me to use the hockey stick though, it wasn't that I saw it then decided to use it. I kept the broken hockey stick in my garage for a while thinking I could use the wood for something in the future and see it every now and then. Perhaps that is why I remembered it.

Everyday repairers also iterate and experiment as part of the design process. For example, a participant describes how her boyfriend tried first using their juicer's cracked waste collector before attempting to repair the broken part. Based on the

Fig. 2. Replacing a juicer's broken waste collector with a plastic bag.

unsatisfactory outcome of using the broken waste collector, he resorted to using a plastic bag (as a replacement) and found that the solution worked quite well (see Figure 2).

Unique competences observed in the practice of everyday repair include impromptu and in-situ problem solving approaches. For example, one participant describes his impromptu repair approach when he tried to find a replacement for his popcorn maker's missing butter dish.

> I don't remember why I decided to use tin foil on the popcorn popper. I remember trying to make popcorn once without the butter tray, and popcorn got all over the kitchen. Aluminum foil might have been the first thing I tried.

The competence of implementing quick fixes and thereby creating ad hoc solutions for repair also influences the materials chosen for repair. This process speaks to ways individuals recognize the potential use of materials within their everyday settings for repairing their objects. Individuals may recognize similar properties of a material for replacing a broken object's part. This is a typical scenario with nondigital objects whose physical materiality and properties are well understood by their owners and thus, can be replaced by other everyday materials. In our study, two everyday repairers use common household products, namely plastic bags and tin foil to replace parts of their appliances. In the practice of everyday repair, we rarely observed individuals sourcing specific materials away from their near environment; rather they use materials that are readily accessible around them.

The choice of material is not only based on the necessity of its attributes or its accessibility, but is also a reflection of what materials can be transformed with the techniques known by practitioners. Everyday repair practice exhibits techniques such as reconstructing, replacing parts, and transforming objects. Knowing how to reconstruct a broken object often leads to their restoration. As an example, one participant describes how her father disassembled and reassembled her dysfunctional pencil sharpener in order to dislodge a part that was stuck. Another participant highlights the reconstruction of the window crank of his skylight in order to clean and oil it, thus making it less frustrating and easier to use.

Fig. 3. The flexible material of the strap is tied to the buckle.

In everyday repair, some broken objects require the replacement of missing parts that are vital. This competence focuses on materials that are deconstructable in the sense that individuals can dismantle them in order to access broken parts inside. Broken parts of objects are used as replacement parts for other broken objects that need substitution. These replacement parts are either made as standardized components or deemed simple and adaptable enough to be jury-rigged from other objects. One participant describes how she repaired her broken sunglasses by replacing one of its missing screws with one that was taken from another pair she liked less.

> [I repaired] my favorite pair of sunglasses that I got for $5. It was missing a screw at the time of purchase so I took a screw from another pair of sunglasses (as I didn't mind breaking it for this pair), and now it is all in one piece.

In general, everyday repairers rarely use tools other than their own hands. The considerable limited use of tools in everyday repair speaks to the improvised, less technical nature of everyday repair, as well as to the more simple ways of resorting to resolve the broken stage of an object. The practice of everyday repair includes competences that do not require the use of tools such as warping, bending, folding, and flattening. These competences, however, dictate what kind of objects can be repaired that way. Material attributes include those that are flexible, as observed from objects that were tied or woven together as a means of joining them or transforming their overall structure. For example, a participant was able to repair his leather bag strap by tying it to the buckle (see Figure 3).

The use of the body, hands in this case, reveals yet another material that is central to the practice of everyday repair and that relates to the element of competences. The competences of everyday repair can be actualized because hands can transform and reconstruct broken objects most of the time. When materials cannot be modified with hands, for example in the case of electronic objects such as cell phones and computers, the practice of everyday repair becomes almost nonexistent.

In addition to using hands, some techniques in everyday repair require the use of basic tools. For everyday repairers, techniques of joining usually involve quick-fix/anything-goes types of approaches to gluing, sewing, and taping of objects onto their original substrates. These abilities are everyday skills that do not require anything more than typical household tools like a stapler or a glue stick. As stated earlier, everyday repairers often deconstruct (take apart and reassemble) objects in order to cut them down, perforate them, or unscrew components for repair. Again, household tools or kitchen tools are generally used, and in a few cases handyman tools are used in order to carry out techniques such as cutting wood.

The previous description of techniques of repair (deconstructing, reconstructing and joining) illustrates well the tension that exists between techniques and tools in everyday repair. It is clear that the techniques known and performed by practitioners only require tools that are accessible in a household. However, it is not evident whether known techniques are not utilized since the required tools are not available or, on the contrary, if available tools constrain the techniques chosen by everyday repairers. Additionally, we have not observed instances where individuals start to learn new techniques or use new tools in order to repair a broken object. It seems that individuals do not feel the need to expand their know-how. They feel they can accomplish what they need to with the tools and techniques they already possess.

In summary, we observe that the physical attributes of everyday repair objects and the tools used are closely interrelated to the knowledge and competences of everyday repairers. Objects and materials are repaired or used based on the ability of the individual to transform the object with everyday skills.

4.2. Green-DIY

Practitioners of green-DIY approach projects with a vision of sustainability, that is to make new things sustainably. This strongly influences the choices surrounding how projects are approached and accomplished. We describe meaning, material, and competence within the practice of green-DIY and further highlight interdependent relations between those elements, and more precisely the effect of meaning on other practice elements.

4.2.1. Meaning. Meaning is the most influential element in the practice of green-DIY. It draws deeply on the personal and ethical values of its practitioners. Demonstrating a greener lifestyle and expressing a sustainable identity inspires others and can lead to wider change. Inspiring others is a motivation in its own right and is an incentive for contributing and participating in green blogs. One participant highlights this in the following email response.

> Right now I believe my role is to continue learning and creating crafts on Crafting a Green World that can inspire people to make a change.

In addition, in a response to our email questionnaire, an author of *Crafting a Green World* wrote the following.

> I love inspiring our readers to take everyday items and [. . .] upcycle them into something amazing. I realize not all of our readers recycle, so if I can inspire [one] reader to reuse "trash" and turn it into treasure, I feel I've done my job!

Aesthetic qualities play a role in projects of green enthusiasts; to craft something beautiful is motivating and the aesthetic quality of an object inspires others to create new value with old or obsolete materials and objects. Meanings are often entangled with each other but can lead to complementary benefits. For example, individuals who reduce their use of chemicals and toxic products in the home lessen detrimental impacts on the environment and also benefit from creating a healthier environment in the home. Green-DIY enthusiasts pursue sustainable lifestyles that typically lead to the positive side effect of saving money. For example, many posts suggest ways to "reduce your impact on the planet and at the same time reduce the impact on your wallet".[2]

[2]http://greenupgrader.com/880/5-cheap-easy-ways-to-go-green-save-green/.

Mediating between different types of meanings can also be challenging for green enthusiasts. For example, one author from the blog Crafting a Green World highlights how helpful a manifesto can be. He describes it as follows.

> [A] clear, guiding philosophy through which you can mediate between your sometimes competing identities as an environmentally conscious person and as a person who thinks crafting up cool stuff is awesome.[3]

4.2.2. The Relationship of Competences to Material. In green-DIY, materials are mainly chosen based on their sustainable characteristics or environmental effects. Materials that are able to be recycled or repurposed and hold the qualities of being nontoxic, natural, fair-trade, and vegan are chosen over nonsustainable or unknown materials. For example, a blog post proposes vegan alternatives to bee wax such as carnuba, soy, bayberry and candelilla wax.[4] Practitioners also create their own products to fit sustainable characteristics. For instance, we observed posts explaining how to make natural glue with water, flour, cornstarch, sugar, and vinegar.[5] Green-DIY practitioners often use materials like egg cartons, toilet paper rolls, newspapers, plastic containers, and tin cans.[6] Multiple meanings are behind these choices, the materials are recyclable or upcyclable and since they are easily accessible in the home they help reduce overall household waste.

In some cases, specialized sustainable technologies are necessary for green-DIY projects. Such materials are generally used in more complex projects. For example, when making portable solar panels, green enthusiasts need to buy solar cells that meet the technical aspects of the project.[7] While it may seem obvious, it is important to note that the aspiration to lead a sustainable lifestyle limits the choice of materials, which in this case is an energy source. As we know there are conflicts in these choices, such as considering the environmental impact of the eventual disposal of the solar panels versus batteries that are assessed through the lens of the aspirations of the green-DIY practitioners.

4.2.3. Competences and the Linkage to Meaning. When approaching a green-DIY project, certain competences are necessary for its execution. In most cases, practitioners need to have some inspiration, imagination or a vision of a project first. For example, an author shares her inspiration in a post as following.

> This week my mom brought me a bunch of garage sale goodies! Among all of the treasures were two oval embroidery hoops. As soon as I saw them, I thought they looked like eggs so I decided to upcycle them into adorable Easter eggs![8]

In order to come up with a vision for a project, an explicit and critical aspect of green-DIY practice is learning from other people's experiences. This fits well with the goal of encouraging others to be sustainable. Authors share their knowledge in the form of tutorials for readers to learn. Readers not only learn different techniques but learn along with other practitioners in experimentations and iterations of a project. In addition to tutorials, many green enthusiasts describe trial and error attempts of making a project in their blog posts. Blog readers share their approaches and knowledge in comment sections describing their own attempts and ideas related to the author's project. For example, an author's post on Simple Organic describes her various attempts

[3]http://craftingagreenworld.com/2008/10/21/a-green-crafting-manifesto/.
[4]http://craftingagreenworld.com/2012/02/29/vegan-beeswax-alternative.
[5]http://craftingagreenworld.com/2011/01/31/five-recipes-for-natural-glue.
[6]http://simplehomemade.net/starting-a-garden-with-repurposed-materials.
[7]http://www.instructables.com/id/DIY-Portable-Solar-Panels/.
[8]http://craftingagreenworld.com/2012/03/23/how-to-embroidery-hoop-easter-eggs/.

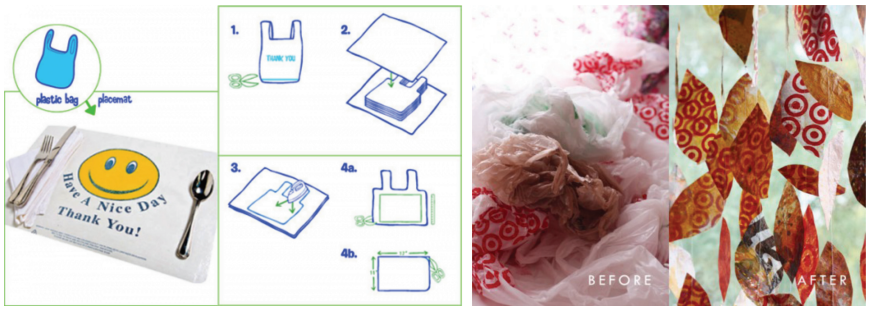

Fig. 4. (a) Flow diagram to make fused plastic bag fabric by Tiffany Threadgould and (b) plastic leaf garland[11] by "Aunt Peaches".

of creating a chemical free grease remover with readers leaving 59 comments to share their own experiments, defeats and successes.[9] Collaboratively developing competences and sharing information is driven by the need to encourage as many people as possible to have the capacity to act sustainably.

Transparency of techniques and know-how contributes to the goal of learning and sharing. Green enthusiasts plan different steps and actions, and make efforts to share those. For example, an author of the Green Upgrader wrote the following.

> Since I've been digging up info about eco-friendly roof options, I thought I'd share what I found with you guys![10]

Another example shows a flow diagram of how to turn plastic bags into 'fused plastic bag fabric' in order to make different upcycled craft projects such as leaf garlands (see Figure 4).

Hands-on competences such as reconstructing, replacing parts and transforming objects are common green-DIY projects as are examples of how to perform these. Reconstructing sometimes means taking apart sections and reassembling them in different ways. For example, one post shows how to cut an old sweater and sew it back together to make a scarf.[12] Replacements can be a real opportunity for using sustainable alternatives. For example, some tutorials suggest replacing current water heaters with more energy-efficient[13] ones or exchanging incandescent light bulbs with eco-efficient[14] ones. These examples illustrate how the sharing of knowledge and competences also include information about sustainable materials.

Using online tools is a fundamental aspect of green enthusiasts' promotion of green living and information sharing. Within green blogs, we observed three strategies authors use for augmenting the ways they shared information. Most blogs use social media networks such as Facebook, Twitter, and Pinterest to disseminate information. This also allows readers to repost, like, tweet or pin articles they like to share within their own social circles. Furthermore, blogs allow readers to post comments on an article's page, providing a space for discussion between readers and authors. A reader of Simple Organic says this.

[9]http://simplehomemade.net/how-to-naturally-try-to-get-grease-stains-out-of-laundry.
[10]http://greenupgrader.com/17558/eco-friendly-roof-options.
[11]http://greenupgrader.com/22015/fused-plastic-bag-crafts.
[12]http://greenupgrader.com/18002/craft-recycled-5-ways-to-repurpose-an-old-sweater.
[13]http://greenupgrader.com/19309/8-innovations-for-home-energy-savings.
[14]http://greenupgrader.com/880/5-cheap-easy-ways-to-go-green-save-green.

> I try to comment on posts that speak to me. I think that it helps with bringing more of a community to a blog. It is what I hope for my own blog as well.

Green blogs are connected with other blogs and Web sites, creating a larger network of interrelated sites that share interests with regards to promoting a more sustainable future by storing and providing information. For example, when readers leave comments, they usually have the option of including their own Web site or blog URL. The use of online tools for sharing projects and visions reveals the influence of the general motivation and aspiration in green-DIY. In addition, knowing what is good or bad in relation to sustainable living is a prominent competence of green enthusiasts with regards to making conscious decisions. A member of Instructables for instance posted a list of 20 ways to be green in order to give advice and information to others[15] and another practitioner posted an instructable on what people can do to stop global.[16]

We observed green enthusiasts using a wide range of techniques for accomplishing their projects. Some examples are adhering, deconstructing and augmenting including gluing, taping, sewing, soldering, and cutting. Enthusiasts were comfortable with multiple physical tools borrowed from varied domains such as craft, handyman, and household tools. However, it is not necessary to have particular tools, alternatives can be found or appropriated to perform a needed technique. Although green-DIY practice requires certain skills, techniques and tools, they rarely influence the realization of projects. Practitioners are fairly ambitious, tackling projects with the tools and skill sets they have, a reader of Green Upgrader describes

> The project type and its potential place in my life are what influence me. I am pretty handy and I scavenge materials a lot, so tools, techniques etc aren't a huge factor. I will consider doing it if it is useful and germane.

This point shows that competences and materials, like tools, play a lesser role than the meanings behind green-DIY. Practitioners emphasize the symbolic meaning of materials and the aspirations of sharing, demonstrating and creating sustainable living over correct techniques and specialized tools.

4.2.4. Implementing Elements from Other Practices. Green enthusiasts are eager to share information and projects, and learn from other practitioners. Furthermore, we observed the willingness to implement elements from other practices. For example, we found many examples of gardening and growing food in green blogs (see Figure 5). Examples include outdoor, indoor and vertical gardening, often created with repurposed materials.[17]

When elements of another practice are incorporated, practitioners filter these new materials and competences in accordance with the various meanings of green-DIY. In the case of gardening, know-how, techniques and materials are adapted. The aspiration of creating a sustainable environment excludes unsustainable gardening practices.

In summary, the element of meaning has a strong influence on the choices we make on materials and competences. These choices are based on the motivational aspects and aspirations in green-DIY. Competences for accomplishing a project are not as strongly related to the element of material as one might assume. Green enthusiasts are flexible and ambitious in their projects; they are not concerned with how to get something done but they rigorously adhere to the meaning and aspirations of their practice.

[15]http://www.instructables.com/id/Top-20-ways-to-be-green.
[16]http://www.instructables.com/id/How-to-Do-Your-Part-to-Stop-Global-Warming.
[17]http://simplehomemade.net/starting-a-garden-with-repurposed-materials.

Fig. 5. Examples of DIY gardening[18]. From left to right: vertical shoe organizer garden by pippa5, self watering thermal insulated mini greenhouse by mapmg, used tired raised garden by auntwrenny, and mini-greenhouse by kcrox1017 (all images from instructables.com[19]).

5. DISCUSSION

At this juncture of our article, we want to explore the potential relationship between SID and practices like everyday repair and green-DIY. Here, we aim to answer our second question: what is the role of interaction design and design fictions with sustainable practices like green-DIY and everyday repair? A response to this question hinges on an understanding of practices and raises the issue of how practices transform and evolve. We first extend our discussion of practice theory to convey the dynamics of practices and how they transform over time. This is an important theoretical component that adds to the analysis of our illustrative cases. With practice theory as a theoretical backdrop, we explore the role of interaction design to enable practices through reconsidering the design of tools and materials.

It is important to note, as we stated in the introduction, that as designers we accept the emergent qualities of practices that limit prescriptive and instrumental views of the impact of technology and design. Even the most considered intervention leads to unpredictable and unintended effects that can be difficult to understand and assess. Any design interventions at the level of process or directly on practices themselves operates dynamically and interdependently. This calls for ongoing, experimental, and iterative interactions with practice that embrace degrees of uncertainty but acknowledge the inevitable influence of design on practices.

5.1. Innovation and Transformation

Practices are dynamic. Accordingly, if we want to design towards sustainability, we need to understand how practices are transformed and how innovation happens within sustainable practices. With our illustrative cases, we provided descriptions and observations of practices-as-entities, observing them at one point in time. This section will distance itself from the examples, as they cannot provide evidence of dynamic practices, however it is intended as a theoretical foundation for Sections 5.2 and 6. Providing a full account of the dynamics of practices is a tall order. Fortunately it is tackled well and in detail by Shove et al. [2012]. We provide the briefest summaries of their work given the limits of this article, and we do so with caution of the oversimplification that is unavoidable in such an overview.

Practices emerge, evolve, and disappear [Shove et al. 2012]. Each element of practice (meaning, material, and competence) can progress differently and each can be the cause for transformation or innovations within practices. Changes can happen within the performance of activities, reversing the typical roles of producers and consumers (or designers and users) and highlighting a more active and ongoing relationship

[18]http://greenupgrader.com/8601/10-killer-diy-garden-hacks.
[19]http://www.instructables.com/.

between them [Shove et al. 2012, p. 12]. Warde [2005] explains that by definition practices are reproduced and sustained because of the conventions and habits that frame them. However, practices also include a constant factor for change. Because multiple individuals perform each practice and every performance has the potential of stepping outside the conventions, bringing in new elements from other practices such as adding different materials or incorporating competences. With regard to SID, we inquire to see where innovation can happen in daily practices and how these transformations can lead to more sustainable practices.

Shove et al. [2012] argue that policy approaches aimed at behavioral change emphasized individual choice, overlooking many factors that a practice-oriented approach reveals [Shove et al. 2012, p. 18]:

> [. . .] establish that most such programmes depend on viewing behaviour as a matter of individual choice, typically based upon personal attitudes but sometimes influenced by 'driving' factors, including social norms, habit and more rational considerations of price. This conceptualization of action overlooks the extent to which the details of daily life are anchored in and constitutive of the changing contours of social practice.

Shove et al. [2012] promote that interventions can change social practices by reconfiguring their elements. For example, they examine a policy intervention known as CoolBiz. CoolBiz is a successful environmental campaign by the Japanese government that limits the use of air conditioning by changing social and cultural structures, like advocating for a change in attitude and dress codes for business [Shove et al. 2012, p. 146].

> [. . .] actors [. . .] can and do influence: a) the range of elements in circulation; b) the ways in which practices relate to each other; c) the careers and trajectories of practices and those who carry them; and d) the circuits of reproduction.

In essence, we assume that designing for change can happen by enabling practices to evolve, given the following conditions.

—Practices are dynamically arranged and always in a process of forming, reforming, and deforming. Elements of practice are by comparison stable however the links among them, which constitute practices, are in a process of breaking and reattaching. For example, craft techniques are resurrected in a new practice of green-DIY. Additionally, the emergence of a new element can cause the disappearance of another in a given practice.
—Practices can change through relationships with other practices. For example, we can see how elements of gardening practices can add new competences and materials that change green-DIY.
—Practices are dependent on the recruitment and defection of carriers or practitioners to evolve or end. Further, design can have a role in recruitment and defection. For example, the lack of reparability of digital devices by everyday repairers fails to recruit practitioners to a practice of everyday repair that includes digital devices.
—Practices rely on reproduction of the entities and performances of practice and the relations between coexisting practices to sustain them and transform, what Shove et al. [2012] refer to as "circuits of reproduction."

Within this theoretical context, we discuss in Section 5.2 the possibility of designing resources to support evolving practices. In Section 6, we invoke the notion of aspirations (meaning) and design fictions as a way to describe how transformations of practices and design may occur.

5.2. Designing Resources

We now explore how SID can be aligned with a practice-oriented approach in light of our examination of green practices. We hope it is plainly evident that designing for practice is not the same as designing for individual behaviors and choices. Designing for practice entails understanding materials, meanings, competences, and the linkages among those elements in order to create resources that support and extend individuals' acquired practices. In practical terms, we see the need for interaction design to shift its focus towards understanding tools and materials as resources for sustainable practices. This in itself may not seem surprising but we remind readers this occurs in the holistic and embodied sense of practice and that design both enables and constrains practices. We also remind readers that practices are uniquely configured so what may work for green-DIY will have no relation to everyday repair. To further complicate matters, the effects of design interventions may well be unknown, unpredictable, and latent. As such we found a number of concerns for sustainable interaction designers when considering the role of interaction design in supporting practices. These include, the challenges of designing for materials or competences; the implications of the body as material; the leveraging, foreclosing and expansion of competences through design; and lastly designing tools for advocacy and learning.

5.2.1. Materials or Competences. Theoretically, the design of materials and tools need to be intelligible to practitioners such that they are inscribed with ways of doing. The inscribing of practice holds a multitude of possibilities, limitations, and improvisations that allow practice to happen or change, while at the same time these possibilities are regulated by the constraints of the practice itself. In practical terms this leads to the interesting question for designers as to whether to design towards competences or towards materials and tools. Is it the knowledge of how to use the tools that makes them part of the practice and available, or is it that because certain tools do not exist, individuals do not develop and extend competences that can take advantage of new tools?

A single answer will clearly evade us. We highlighted this challenge in our discussion of everyday repair in our analysis of competence in relation to materials in Section 4.1.2. We asked whether known techniques are not utilized since required tools are not available or if available tools constrain the competences of everyday repairers? Everyday repairers use few tools and those they use are household tools and on occasion handyman tools. What constitutes a household tool? Or, how is it that certain tools are incorporated into everyday practice and others not?

Interestingly, in our observations both green-DIY and everyday repair practitioners seem to minimize the need for developing new materials or competences. In green-DIY, one participant stated that tools and techniques are irrelevant since green enthusiasts tend to find ways to complete projects because it is the project itself and being sustainable that motivates them (see Section 4.2.3). Everyday repairers demonstrate this tacitly by overwhelmingly conducting most repairs by hand. There also appears to be an inherent limit to the very meaning of everyday repair. If a repair requires materials or competences beyond everyday practice, it is by definition no longer everyday repair and requires expert competence and materials. The challenge for SID is that the latter description is the current status of technological artifacts and as a consequence they tend to go unrepaired and are accumulated for eventual disposal.

We can point to three possible responses to designing resources that will be intelligible and potentially incorporated into practices. The first response relates to our example of green-DIY practitioners who are driven by the meaning of projects and not the tools and techniques. In this particular case there is a need to design resources that can be identified with aspirations, project ideas and symbolic meaning within the

practices. For example, solar panels are a clear example of an energy choice that meets the symbolic meaning of sustainable living even though these may not always be the right choice. Yet as we discuss in the next section it may have the benefit of expanding competences and know-how that eventually lead to better use of materials.

A second response is to design tools to incorporate new or advanced competences. For example, Shove et al. [2007] discuss changes in paint and the impact of the newer material on home improvements. Paints were developed to be self-stabilizing to prevent drips, fast drying to minimize ruining finishes while they were drying, and water-based to ease clean-up and prevent irremovable stains and drops on floors and other surfaces. The expertise of the professional painter to manage drip-free finishes and challenging work sites was incorporated into the material: "The point is, rather, that the aspects of the competence needed to paint the door have been distributed between person and technology, the paint having effectively absorbed capacities previously embodied in the individual wielding the brush" [Shove et al. 2007, pp. 55–56].

Thirdly, we propose designing tools and materials that will knowingly be utilized across practices for altered purposes. In the few instances when everyday repairers used tools, they were kitchen or handyman tools. In effect, tools were 'borrowed' from the kitchen or the handyman's tool chest to repair an artifact. The kitchen or the garage is clearly a site of practice, however we need to consider that a home (or work) is a site of multiple overlapping practices and that practitioners are simultaneously carriers of multiple practices. This type of "cross-referencing" of practices [Shove et al. 2012] is a common occurrence. Materials and competences shift across multiple practices. This is an opportunity for SID.

5.2.2. Body as Material. In relation to materials and competences, we observed the human body as a material of everyday repair practice. Everyday repairers opted to use their hands whenever possible over the use of tools. This extended to the point that when individuals cannot use their hands, the possibility for repair is low. As a consequence, the material attributes of objects accessible to repair included those that could be warped, bent, folded, and flattened. For example, we showed an example of repairing a leather bag by being able to tie the leather handle (see Section 4.1.2). The capacities of the human body alone without tools may limit the types of objects that can be repaired yet this appears to be a constitutive element of everyday repair. In other words, the lack of tool use in the case of everyday repair is not a shortcoming within the practice. Given this, in everyday repair and similar practices, sustainable interaction designers may want to consider thinking of solutions to create technologies that can be transformed with hands or the body.

5.2.3. Leveraging, Foreclosing, and Expanding Competences. We have already discussed the role of competences and their role in enabling or limiting practice. Here we discuss the degree to which designers can leverage existing competences, intentionally or unintentionally foreclose on practitioners' competences, and lastly enable expansion and development of this element.

A general stance for designers is to find ways to leverage existing competences. For instance, we discussed earlier that everyday repairers felt little need to use new tools. It seems similar with competences. We did not observe instances where individuals felt they needed to learn a new technique in order to repair a broken object. This unwillingness to expand competences in everyday repair necessitates a design intervention that leverages existing competences. The lack of repair of digital devices as mentioned earlier is a good example of the stalemate between the everyday repair of such artifacts and the purposely limiting factor of their design. The repair of digital devices requires techniques that far outstrip everyday competences and knowledge of how things work and are assembled. This may seem rational for complex devices yet even relatively

simple repairs such as replacing batteries, broken keyboard caps, and cracked screens require advanced competences.

Designing digital devices to prevent opening enclosures and modifying hardware is intentional. A similar example is given by Shove et al. [2012]. Discussing the history of car driving, the authors explain how practices of amateur repair were effectively minimized and foreclosed upon through design [Shove et al. 2012, p. 35].

> Cars, once important sites of amateur expertise, have been re-designed to prevent tinkering and ensure that relevant knowledge is concentrated in the hands of a very few (e.g., garages with relevant computer diagnostics etc.). People may retain skills acquired through what Borg [2007] refers to as 'under hood' activity, but be prevented from putting these into practice by the sealed boxes of electronic tricks of which cars are constituted today.

Returning to everyday repair, the very limitations of the competences involved and the reliance on hands-on know-how puts the continuance of the practice at some risk. If artifacts or technologies cannot be transformed or repaired with hands or household tools, the practice of everyday repair might be radically transformed or even erased. This will give way to consumption and disposal patterns that clearly are not sustainable.

Designing to extend competences entails the benefit of transforming the practice positively and the individual benefit of increased know-how and confidence in carrying out aims of the practice. We discussed how materials that are compelling to practitioners in relation to the meaning of their practice like solar panels extend the know-how and overall competences of the green-DIY practitioner. Designing with transparency of techniques and particular knowledge related to the artifact extends competences by contributing to the goal of learning and sharing. We found this in the cases of one green enthusiast sharing what he found on eco-friendly roof options and another practitioner sharing a flow diagram that illustrates how to turn plastic bags into fused plastic bag fabric (see Section 4.2.3).

5.2.4. Advocacy and Learning: Sharing Tools. Interaction design can have a role in continuing to design and evolve information sharing tools to help green-DIY and similar practices to learn, share and generally advocate for change. Without these information sharing tools, critical reflection and knowledge transfer may not happen or happen less frequently and robustly. This is reflected in the choice of media rich online tools that include forums, blogs, photo-based tools, and video services, to promote one's green lifestyle to others. This is supported by the meaning of inspiring others and promoting a green lifestyle. Blogs, photo and video based tools are easy authoring tools and their diaristic structures support reporting in the practice of green-DIY well. Commenting functions further green-DIY to ensure the participatory nature of the discourse. Allowing and encouraging comments and feedback ensures that knowledge is actually exchanged amongst practitioners rather than just imparted. Accordingly, current tools meet the demands of both meanings and competences.

The characteristics are important because they demonstrate embodied learning in how practices are taught and passed on [Bourdieu 1977; Schatzki 1996]. Therefore, online tools extend the ability of embodied and experiential learning which has had a significant impact on the promotion of practices like green-DIY.

In conclusion, in advocating for designers to design resources, we suggest that designers understand they are designing for practitioners who operate within and across uniquely configured practices. Further, the practical aim is to design materials and tools that make sense within the specific practice, that is, that are intelligible with what is known and embodied at the time, yet are also capable of not only supporting the actions of practice but allow for change of the practice itself. Moreover, it should

Fig. 6. Vertical walls, a) on Musée du Quai Branly, Paris (photo by snoeziesterre on Flickr.com) b) created with a wood pallet (photo by Stephanie Booth on Flickr.com).

be considered, that practices are dynamic systems encompassing inequalities among linked materials, competences, and meanings depending on the nature of the practice.

6. DESIGN FICTIONS: REIMAGINING PRACTICES

So far in this discussion we have pursued the practical contributions SID can make to sustainable practices in the light of practice theories. As promised, we now turn to exploring practice theory coupled with design fictions to form a generative approach that moves beyond informing current interaction design to ways of reshaping it to be more open, participatory, and innovative. In this section we explore the intersections between the practice of green-DIY, design, and design fictions. As we discussed in 2.3, design fictions take the form of narratives, prototypes, and concepts that project a design idea represented in a future situated action and so here we discuss three such examples of DIY and design exemplars or fictions.

In our first example, we look at vegetal walls that show a clear link between the practice of green-DIY and the design fields of architecture and landscape architecture. Green enthusiasts are interested in design and search for examples and inspiration in projects made by designers and architects. Vegetal walls and garden pallets provide an example of how green enthusiasts reinterpret professional projects and make them their own. Vegetal walls were invented and patented in 1988 by Patrick Blanc, a French botanist, architect and designer. They are a luxurious, artistic, and aesthetic way of growing plants on vertical surfaces on urban buildings (inside or outside). A famous example is the vegetal wall at the Musée du Quai Branly, in Paris, built in 2004 (see Figure 6(a)). Vegetal walls require technologically advanced systems to control watering as well as engineered substrates and structures to support them. They typically require large investments and ongoing maintenance. In other words, they are complex projects that involve innovations in technology, engineering, and landscaping. The benefit aside from aesthetics is that they are environmentally sustainable in terms of reducing the thermal load of buildings, reducing the heat island effect, and absorbing storm water.

This concept and its sustainable benefits have influenced green enthusiasts to reproduce vegetal walls, however on a different scale and with radically different and simpler means. In this tutorial[20], the author mentions that Blanc's walls inspired his project.

> Garden walls or 'vertical gardens' have gained a lot of notoriety over recent years with designers such as Patrick Blanc setting the standards. Vertical gardens can come in all shapes and sizes, some scaling

[20]Bridgman Furniture and Outdoor Living Blog is a site that showcases new design for domestic living http://www.bridgman.co.uk/blog/diy-vertical-garden-wall.

Fig. 7. Bosco Verticale (Vertical Forest) by Boeri Studio (Stefano Boeri, Gianandrea Barreca, Giovanni La Varra).[21]

entire buildings, whilst others sit in offices, gardens or private homes. Below I would like to show you how you can create your own vertical garden using a wooden pallet.

A reused wood pallet is employed instead of the high-tech materials and engineered structures that constitute the large-scale projects by Blanc (see Figure 6(b)). Green-DIY practitioners understand the concept behind vegetal walls, and many other professionally designed artifacts; they are able to reverse engineer their construction into similar projects. In this case, they reinterpret the idea in order to make a vastly simpler version of a vegetal wall that holds similar benefits. The aspiration behind the project is kept the same as the original vegetal walls (growing plants on a vertical surface), however the materials are changed to fit the green-DIY requirements (a recycled pallet for example) and map to the competences of green enthusiasts.

Blanc's walls serve as visions of a possible future for gardening. Many other exemplars and design fictions of vertical gardening serve as inspiration for green enthusiasts. For example, the architecture firm Stefano Boeri Architetti presents a concept of a vertical forest to foster the reforestation and regeneration of biodiversity in the urban context of Milan, Italy (see Figure 7).

These examples create beautiful visions that inspire many green-DIY practitioners to take action and create their own versions of these concepts. However, these professional visions of vertical gardening and vegetal walls still questions as to how sustainable they truly are. The amount of money and infrastructure needed to start a project, as well as the amount of water required to keep the soil moist against gravity, and the power used for the management system are all factors that can call into question the environmental benefits of such systems. However, when looking at the versions created by green enthusiasts, the use of repurposed materials and the much smaller scale minimize many of these problems, rendering the idea of vegetal walls or vertical gardening by green-DIY enthusiasts a more sustainable practice.

In this example we can draw several points, chief among them is that meaning plays a central role in practices like green-DIY and this in turn encourages the incorporation of inspirational examples and design fictions. Both resonate for practitioners in terms of symbolic meaning and in meeting the aspirations of practice. Design fictions themselves are based on meanings and illustrate possible futures by emphasizing and extrapolating values that may align with the aspirations of practitioners.

[21]http://www.stefanoboeriarchitetti.net/?p=207.

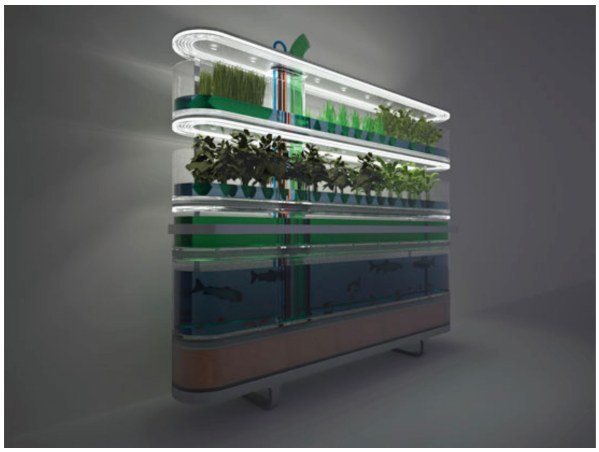

Fig. 8. Home Farm design concept, from the Philips Design Probes program ©Philips.

In green-DIY, the prominence of meaning separates means from ends. As we saw in our examples, many practitioners paid less attention to materials and competences, finding alternatives and exploiting accessible means to achieve a project. This separation of means and ends proves advantageous in the case of vegetal walls. Green-DIY practitioners simply ignore the technical demands of the professional vegetal walls by substituting them with known and accessible competences and materials.

Our second example demonstrates more specifically how designers can play a role in bringing design fictions towards the practice of green-DIY. Aquaponic farming combines aquaculture (raising fish in water tanks) and hydroponics (the production of plants with and on water) in an environment where one part feeds the other. Philips created a Biosphere Farm, a diegetic prototype of an aquaponic system for the home that "stack[s] the various mini-ecosystems on top of each other"[22] (see Figure 8).

The image has been presented on many blogs and newsfeeds on the Web, where authors present the idea to readers. For example, in Mail Online, the project is presented as a way of producing food in the kitchen of the future. They acknowledge that the project is a vision that may look like science fiction: "It sounds like the stuff of science fiction, but this sort of technology is already under development to help households take the pain out of going green."[23]

Design fictions are generally aimed at an audience of technologists and designers who can reason on how the future can or should be and discuss possible technologies, materials, and the mechanisms involved. However, green enthusiasts see these design fictions as possible futures that are accessible for immediate reimagining and construction. For green enthusiasts, design fictions are like any existing design object, therefore they become a source for interpretation and adaptation into a new and immediate DIY project. For example, the Web site Green Global Travel[24] also presents the Biosphere Farm project by Philips, but specifically as a tip for green-DIY adding that "anyone can do it": "There's even better news: ANYONE can do it. Aquaponics systems range

[22]http://www.design.philips.com/about/design/designportfolio/design_futures/food.page.
[23]http://www.dailymail.co.uk/sciencetech/article-1219701/The-DIY-fish-supper-Future-kitchen-grows-vegetables-seafood.html.
[24]http://greenglobaltravel.com/2012/01/20/go-green-tip-82-diy-aquaponics-the-future-of-green-gardening.

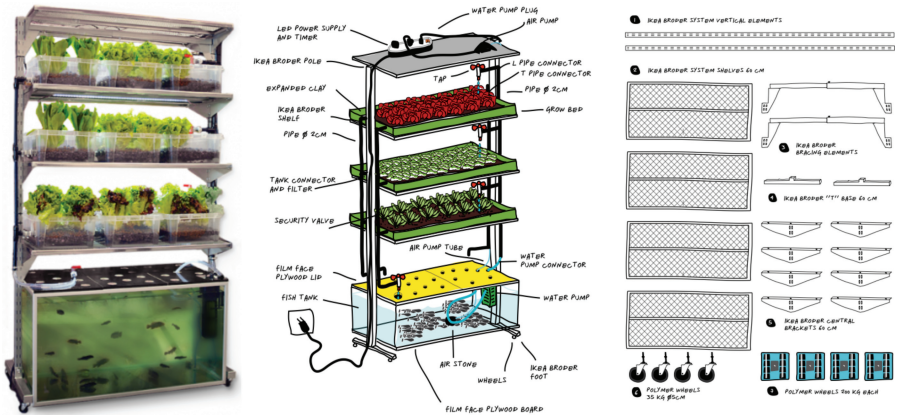

Fig. 9. *Malthus*. An in-home aquaponics system by Conceptual Devices (Antonio Scarponi).[27]

from small indoor setups to large commercial units, making aquaponics suitable for everyone from small-scale gardeners to large-scale farmers."[25]

Designers can take an intermediary role between design fictions and sustainable DIY practices. Malthus[26] is a DIY home version of aquaponic farming (see Figure 9). It was designed by the firm Conceptual Devices. The project aims to show how to build an aquaponic farm with accessible and easy to assemble materials. In this case, the designer is not presenting a design fiction in itself, but a plausible prototype of a proximate future.

Similar to the vegetal wall examples, this prototype eschews high tech and specialized materials. It uses resources that are available in DIY stores or at IKEA. The designers clearly identify the required parts, and the electronics necessary to construct the system (see Figure 9). This example illustrates how designers can translate between visions of the future and ways of making projects realizable today by other practitioners, namely DIY enthusiasts.

Such a designer may be considered to truly be a practice-oriented designer. The design approach adopts the transparency of "open source" to best address the practitioners for whom the design is intended. This type of designer can influence the practice of green-DIY by providing instructions, examples, and lists of accessible parts that in the process introduces new materials and competences in a way intelligible to practitioners. This model of a hybrid or intermediary designer can readily apply to other design domains like the design of interactive technologies.

This example reveals how elements from other practices can be introduced through design fictions. In addition to gardening practices, aquaponics become a realizable addition to green-DIY when it is adequately motivated in a design fiction that aligns the new practice with the meanings of green-DIY. As we stated, design fictions are typically aimed at designers and technologists as a projected end from which the means need to be researched and developed. This example shows how in the intersection of design fictions and green-DIY, the idea of audience is disentangled and leads to unexpected and interesting innovations. Green-DIY enthusiasts read the design fiction through

[25]http://greenglobaltravel.com/2012/01/20/go-green-tip-82-diy-aquaponics-the-future-of-green-gardening.
[26]http://www.conceptualdevices.com/2011/06/malthus-a-meal-a-day-or-how-i-learned-to-stop-worrying-about-the-food-and-love-the-population-bomb/.
[27]http://www.conceptualdevices.com/2011/06/malthus-a-meal-a-day-or-how-i-learned-to-stop-worrying-about-the-food-and-love-the-population-bomb/.

the lens of green-DIY practice regardless of the fact that they are not the intended audience.

The opened space between design fictions and DIY practices allows for a hybrid practice-oriented designer. Such a designer conceptualizes and prototypes new ideas employing a level of transparency and making that align well with DIY practices. This new designer is a model for a sustainable interaction designer.

Our third example presents a different role for the designer, one where she is a facilitator for a collaborative practice between everyday people and designers. Collapse informatics is "the study, design, and development of sociotechnical systems in the abundant present for use in a future of scarcity" [Tomlinson et al. 2012a, p. 655]. The scenario of a virtually complete collapse of our global information system can be seen as a design fiction that imagines what would happen if our sustainability efforts fail [Tomlinson et al. 2012b]. The scenario imagines that global warming occurs beyond the tipping point and, as a result, all our systems start to fail.

This fiction, however, can help us today in thinking about the types of systems that would be necessary for us to adapt to this type of event. As an example, the Domestic Plant Guild Project [Norton et al. 2012] assumes a world where resources are rare and infrastructures have collapsed. In this scenario, it would be very difficult to grow plants for food that are not native to where they are being grown. If people knew how to create plant guilds (a group of plants that mutually support each other and help the eco-system to strive), they would be able to grow food locally that would sustain them where they are, with less energy requirements and few resources. However, understanding how to make these guilds typically requires expert knowledge and time [Norton et al. 2012]. The Domestic Plant Guild Composer supposes that HCI can create tools to support the acquisition and distribution of this knowledge and competences needed to create plant guilds anywhere in the world, which would encourage a local and sustainable practice for growing food [Norton et al. p. 2]:

> Therefore, if we can provide support tools to make it easier for people to develop and establish domestic plant guilds, then the gap between the idea of sustainable environments and their realization can be reduced.

In this case, the design fiction and the design solution revolve around the element of competence and how it is distributed. The plant guild composer can become an illustration of a collaborative, participatory, and egalitarian practice between designers and DIY enthusiasts [Tomlinson et al. 2012b, p. 54]:

> Additionally, the PGC has the opportunity to be more than a design tool; it can strengthen a sense of community ownership by letting users share their experiences via an online community. It can increase longevity of knowledge of how to build, design, and use plant guilds by giving users creative control within the computer-aided design process.

To summarize, we see design fictions as a response to bridging sustainable practices and interaction design. In this section we firstly identify the green enthusiast as a person who uses design as a way to inform practice. We then proposed a new model for a hybrid designer who includes open source strategies and DIY materials within his interpreted designs of design fictions. And finally, we proposed that designers can play an important role in a collaborative sustainable practice.

In relation to practices, design fictions resonate well with practices in which meaning is the key element of practice. These type of practitioners read design fictions through the lens of their own practice, ignoring the challenges put forward to the intended audience, substituting their own competences and materials to realize an instance of the fiction. Design fictions can introduce new practices and as a consequence, new

materials and competences that can help evolve and sustain practices. Meaning is the main motivator for incorporating these new practices.

7. CONCLUSION

In this article, we argue that an approach informed by practice theory coupled with design fiction uncovers new roles for and a reframing of interaction design with respect to environmental sustainability. We believe that a practice-oriented approach can help interaction designers step away from models of individual behavior and studies of artifacts towards seeing sustainable behaviors as parts of multidimensional and interrelated practices. We describe the practices of everyday repairers and green enthusiasts in terms of material, competence, and meaning, and the interrelations between the elements, using Shove et al.'s [2012] framework. We show how practice theory can be an analytical tool that identifies means of innovation and transformation that in practical terms for interaction design shifts emphasis toward understanding the design of tools and materials as resources for sustainable practices. We offer with the addition of design fictions to practice theory, a generative approach that suggests a more open, engaged, and participatory interaction design that leads to a level of radical rethinking of the role of interaction designers and the nature of interaction design itself with respect to sustainability.

In the context of everyday repair, we found that the relationship between competence and material is the most important observation for interaction designers. We see everyday repair as a practice in which interaction design can resource through supporting repair with artifacts and systems that embody common competences, simple materials, and require little tool-use for disassembly and manipulation.

Green-DIY was found to be centered mostly on the element of meaning, entailing the personal and ethical values of practitioners. Sustainable aspirations motivated green enthusiasts to learn a new technique or skill and guided the choice of material. In addition, meaning drove green enthusiasts' practice to be outward facing and reflective on its own practice. These characteristics show a role for the design of information sharing that supports promoting, sharing, and constructing identities and lifestyles that are sustainable and support the sharing of embodied aspects of green-DIY practice.

We reveal that these practices are configured uniquely and this sets up reflections on the role of interaction design with sustainable practices like green-DIY and everyday repair. Understanding that practices are dynamic and that their elements can change in time and reconfigure the practices themselves is a starting point for redefining the roles of SID. Designing towards resources and tools for existing routines and actions can support a better integration of practitioners' competences and skills.

In addition, we see interaction design turning to design fiction as a designer's response to practice theory, which can bridge meanings of sustainable practices and interaction design. We recognize how design fictions can be material explorations that can take social analysis in the realm of doing and making as a way of thinking. We distinguish the possibility for interaction designers to become hybrid designers who design with transparent open source strategies and DIY materials. We also see opportunities for designers to work collaboratively with DIY enthusiasts and everyday people at creating solutions for future scenarios. Design fictions can be transformative by introducing new practices and as a result new materials and competences that evolve and sustain practices.

There is of course, more work that is required in refining the emerging concept of design fictions towards design change, especially when coupled with observations of sustainable practices. We see the potential contribution of this work as a viable means for informing future work in SID, and we intend to investigate these approaches further in our own work.

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