CHI 2007 Workshop (W18) Program

Converging on a "Science of Design" through the Synthesis of Design Methodologies

9:00 am – 5:30 pm, April 29, 2007

Guadalupe Room, Marriott San Jose Hotel, 301 S Market St, San Jose, CA 95113

Time Table

8:30 – 9:00	*Pre-workshop informal gathering with Coffee*
9:00 – 10:30	Session 1 (Introduction & position presentations: **8** minutes for each position paper)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Session 2 (Position presentations)
12:30 – 2:00	Lunch
2:00 – 3:30	Session 3 (Discussions)
3:30 – 4:00	Coffee Break
4:00 – 5:30	Session 4 (Discussions)

Session 1 (9:00 am – 10:30 am)

Introduction (30 minutes, by organizers)

Gerhard Fischer: General Introduction
Elisa Giaccardi: Creative Practices
Yunwen Ye: Collaborative Design
Kumiyo Nakakoji: Design Theory and Practice
Chris DiGiano: Participatory design and Learner-centered design
Gerhard Fischer: Meta Design

Participatory design and Learner-centered design (8 minutes each)

1. **OSS Design Communities: An Emergent Form of Distributed Participatory Design**
   Flore Barcellini, Françoise Détienne, Jean-Marie Burkhardt
2. **Designing for Design Learning**
   Melissa Koch, William Penuel
3. **Design of Visual Interactive Systems: a Multi-Facet Methodology**
   Daniela Fogli, Andrea Marcante, Piero Mussio, Loredana Parasiliti Provenza
4. **Using Theoretical Ideas to Stimulate Creativity and Participation in Design**
   Anders I. Mørch

Collaborative Design (8 minutes each)

1. **Design Informatics – Information Needs in Design**
   David G. Hendry
2. **Collaborative Design and the Science of Design**
   Charlotte P. Lee
3. **Combining research strategies in interaction design of communication systems for the home**
   Gueddana Sofiane

Session 2 (11:00 am – 12:30 pm)

Meta-Design (8 minutes each)

1. **Design Methods to Engage Individuals with Cognitive Disabilities and their Families**
   Melissa Dawe
2. **What Cognitive Science Has to Offer for Research on Appropriation and End-User Development**
   Antti Salovaara

Design in the creative practices (8 minutes each)

1. **Complicating HCI/Arts Collaboration**
   Piotr D. Adamczyk
2. **From the Inside Out: Design Methodologies of the Self**
   Thecla Schiphorst
3. **A Participatory Design Understanding of Interaction Design**
   Ron Wakkary

Design Theory and Practice (8 minutes each)

1. **Process and Language for Design**
   Kouichi Kishida
2. **User Experience Building Blocks - Reducing Design to Content Filling**
   Joerg Beringer
3. **The Utility of Simple Prototype Tasks in Understanding and Augmenting Real-World Design Behavior**
   John C. Thomas
4. **Learning from an Extended Context of Patterns in Science of Design**
   Karl Flieder
5. **Design Methodology is not Design Science**
   Christoph Bartneck

Session 3 (2:00 pm – 3:00 pm)

Discussion Sessions are briefly introduced by one of the organizers. The organizer has 5 minutes to summarize themes derived from participants' statements in the morning, and then leads the discussion by all participants.

Discussion Themes

- **Participatory design and Learner-centered design (Chris DiGiano)**
- **Collaborative Design (Yunwen Ye)**
- **Meta-Design (Gerhard Fischer)**

Session 4 (4:00 pm – 5:30 pm)

Discussion Themes

- **Design in the creative practices (Elisa Giaccardi)**
- **Design Theory and Practice (Kumiyo Nakakoji)**
- **30 Minutes: Final Discussion (e.g.: North American vs. non-North American perspectives, did a perspective on a "Science of Design" emerge during the workshop, …)**

Complicating HCI/Arts Collaboration

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INTRODUCTION

We have been exploring collaborative design with Arts and HCI practitioners in the context of several university courses open to both graduate and undergraduate students. Recently we have begun applying lessons from these courses in further explorations of creativity and creativity support tools [2]. Presented here are some of our findings and points for further discussion surrounding the synthesis of design methodologies.

COLLABORATIVE DESIGN

In contrast to approaches that foreground a particular methodology, our courses have used themes as starting points for design discussions. In one instance these themes were mobility and mapping and how both of those broad topics are represented in Computer Science and the Arts [7]. In another we explored how techniques common to site based art can inform the deployment of ambient or ubiquitous computing [1]. Our current course is exploring issues of history and individual/collective memory in the built, and increasingly "smart", environment [6]. Enrollment in these classes is spread across a number of disciplines; for the current course equal numbers from computer science, architecture, and art and design.

These theme (in contrast to methodology) based courses facilitate a particular style of working. When selecting themes we have found it crucial to pick topics that are "neutral" – those which are not immediately claimed by any one discipline. Mapping and memory are clearly a part of computer science but equally part of art practice. In contrast, we've found that a given methodology whether qualitative, ethnographic, quantitative, seems to reflect a more immediately recognizable ideology that can turn-off some students.

Even with appropriately neutral course themes, specific content can be equally crucial. At the outset of our collection of courses we had expected, perhaps naively, that the inclusion of technology would be enough to inspire creativity in the engineers and computer scientists. Similarly we had hoped that artistic elements would be enough to cement buy-in from the sculptors, painters, musicians, and dancers. Instead equally "neutral" content has been best for individual projects. Low complexity physical computing and analog media have proven especially useful when designing projects. These materials have been almost universally unfamiliar, and create a situation where the entire team is on level ground. (Related issues appear in [3, 4]).

Several elements have emerged as important in our model of collaborative design. First the process needs to be productive and "artifactual." By this we mean that the results of the collaboration need to be seen as carrying currency within a given disciplinary practice – resulting ultimately in something that can become part of a publication or portfolio. Our design projects are always "artifactual" in that we require documentation of the collaborative sessions and the various iterations of the design solutions.

Also regardless of disciplinary inclination, the most successful projects have been those that were rigorously positioned, discursive, intentional, and explicit in their design choices.

In many cases the final projects for our courses engage with an audience or situated public. This requirement raises the level of commitment with the students, and also elicits more feedback during prototyping sessions.

WEAKNESSES IN COLLABORATIVE DESIGN

For all of the strengths of our approach several points continue to pose significant problems. Often students are not familiar with the reasons for creating, or are unconvinced of the utility of, material referents. Content instead to keep design meetings highly conceptual and leaving construction to the final stages of collaboration, students sometimes struggle when forced to expose unfinished work to teammates.

Role allocation within teams is sometimes deeply engrained. By choice or social pressure, it is not uncommon for students to reflect "comfortable" stereotypes – the artist does the sketching, the computer scientist does the technology.

Tools to aid design reflection remain difficult to use. Students complain about the state of current creativity support tools or groupware systems, relying instead on more lightweight systems – del.icio.us, flickr, YouTube.

BOUNDARIES TO TOOL ADOPTION

A surprising consistency, given the diversity of our students and their backgrounds, are the boundaries to adoption of

Fig. 1. Low complexity technology and tools provide a common starting point for all students.

Fig. 2. Physical walkthroughs with early prototypes have proven effective.

creativity support tools. Issues like maintenance, overhead, startup time – perceived technological boundaries – exist almost always at the team level. Entire groups come to a quick consensus that the amount of effort is greater than the potential gain. These groups shy away from Wikis and websites, preferring ad hoc methods, often with a single team member relegated to the role of archivist.

When a support tool is rejected by an individual team member it is often due to a "disciplinary culture" boundary. For example, deep commitments to disciplinary myths – a singular creator, or elite coder – can lead team members to ignore the benefits of contributing to an externalized group process.

ADDRESSING DISCIPLINARY DEFICIENCIES

Repeatedly we have been confronted with two disciplinary distinctions: artists are poor methodologically and technologists are poor at evaluation. This is not to say that within their given fields the practitioners lack some fundamental skill; quite to the contrary. It is often the most adept students that are the least open in these collaborative settings. Rather these deficiencies appear when students need to apply a method or evaluate a new project outside of their fields of expertise. Artists in our classes when confronted with a problem of content have had little formal exposure to effective techniques common in HCI – prototyping, cognitive walkthroughs. By the end of the course, they often report these as invaluable. Technologists on the other hand are often familiar with framing problems so that various dimensions are measurable. When dealing with issues of aesthetics and interaction design, the nuanced models of evaluation are often hard to grasp. We are currently exploring methods for bridging these gaps.

EDUCATIONAL IMPLICATIONS

Our approach is fiercely interdisciplinary. Our courses drive home the fact that disciplinary rigor is essential to meaningful contributions, but a solution that is blind to the complex issues surrounding a topic will rarely be useful and hard to build upon. We also provide a venue for new forms of collaboration [9] and participatory critique [8].

These classes are well suited for the exchange of threshold concepts. Threshold concepts in a given discipline have been described as ideas that define critical moments of irreversible conceptual transformation in educational experiences, like *limit* in Mathematics or *irony* in Literary Criticism [5]. By requiring rapid and deep investigation across disciplines, we believe that our HCI/Arts courses provide a space where threshold concepts are necessarily embedded in the collaborative practice.

Some questions we are currently exploring include: How can creativity support tools better convey threshold concepts in artifacts or in parts of the communication process? Can support for threshold concepts be generalized, or is it deeply contextualized?

CURRENT QUESTIONS ABOUT GROUP CREATIVITY

In the context of these courses we have begun a deeper exploration of the role of creativity, creativity support tools, and the science of design. In particular, how creativity might relate to contemporary social theory – Habermas as a primary recent example. Where is creativity situated as a communicative act, what communicative acts are creative, what traits are necessary or sufficient for creativity, and how is creativity recognized in social interaction?

If creativity is "socially-constructed", is there such a thing as a creative individual? Is there a pre-social component to creativity? In common usage "creativity" often assumes a pre-social component - individual creativity. Is creativity an inherent trait that exists outside of social norms or group (perhaps collaborative) practice, however large the group? Perhaps more importantly, is there something about solutions that exists outside of their discourse that makes them creative?

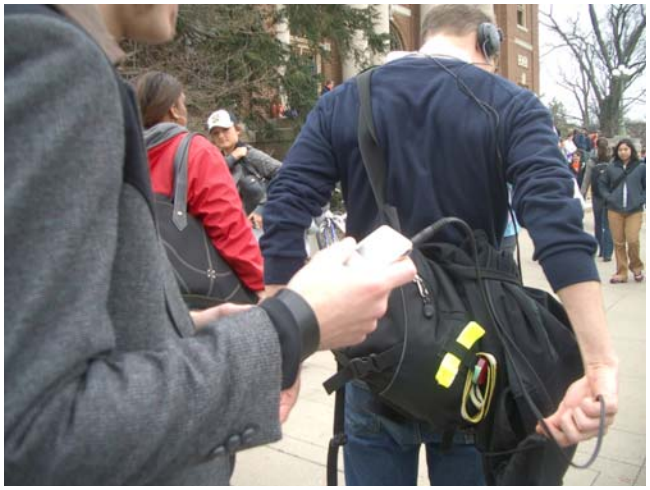

Fig. 3. Siting design problems helps by immediately making design discussions concrete.

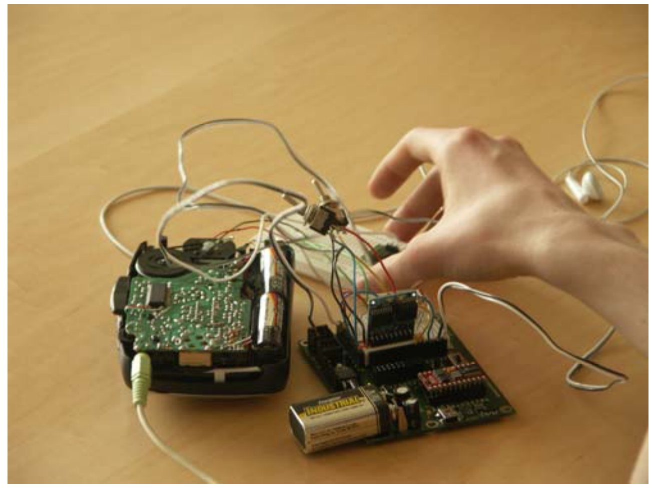

Fig. 4. Artifacts and documentation often convey discipline-specific practice better than discussion.

If we take a creative solution as a communicative act (an extended speech act, or performative) do the structures that let us analyze those acts let us get closer to creativity? As an example, for Habermas, the validity of a speech act rests on the reasons that lend it support. So validity moves beyond truth-conditional approaches to include more ambiguous language – perhaps “creative” language. In these models creativity becomes the unique juxtaposition of methods of appeal, evidence embedded in support of the material, and the expressive act of presentation.

Perhaps creativity resides not (only) in a cognitive appeal familiar to the hearer and embedded in the "standard" solutions, but instead in the expressive communication and in the set of reasons that are implied by the speaker. And the process of creativity rests not in the making, but in the process of bringing about new realizations in the mind of the audience - the construction of a new intersubjective consensus.

ACKNOWLDEGEMENTS

I am grateful for the participants in our experimental courses; their creativity and ingenuity provide a significant contribution to this work. I would also like to thank fellow instructors Laurie Long, M. Simon Levin, Kevin Hamilton, Roy Campbell, and Jonathan Fineberg.

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OSS design communities: an emergent form of distributed participatory design

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ABSTRACT
Our research provides insights about an emergent form of distributed participatory design occurring in open source software communities. Our research contributions are threefold.

The design activity in OSS is oriented toward peer reviewing: our analysis of design discussions oriented toward new design proposals shows that activities are mostly evaluative enhancing the peer reviewing form of OSS design.

The design discussions are framed by key participants: our analysis shows that the project leader and the participant championing a new design idea have key roles in framing the design discussions.

The design activity is a specific form of participatory design: even though design discussions are framed by hierarchical roles, they stay open to all participants, allowing users-pushed design proposals. We have shown that users participation does not guarantee the design to be participatory. It occurs under the condition that cross-participants (an extended notion of cross-posters) in user-oriented and developer-oriented mailing-lists act as boundary spanners between users and developers.

On a methodological level, our research illustrates that the combination of structural analyses (such as social network analysis) and content analyses is necessary to capture the richness and complexity of the OSSD.

Author Keywords
Open source software design, participatory design, content-based methodology, online discussions

ACM Classification Keywords
C4. Design Sudies. H.5.2 User Interface. ergonomics

INTRODUCTION

In traditional user-centered design models, users take part in the design process as informants - in the functional analysis phase- or as evaluators - in the prototype and simulation phases. In Open Source Software Design (OSSD), users can be involved in all the phases of the design process (elicitation of needs and requirements, design and implementation), at least if they have the skills to do so. Hence, in OSSD, users can be highly skilled in computer sciences [5], as well as in particular application domains (e.g., education, biology, scientific computing...). This participation is usually seen as one of the most important factor explaining the success and the quality of the designed OSS. OSSD can be thus considered as a special case of participatory design (e.g. [4]). Moreover, it is a distant and distributed form of participatory design.

The objective of this research is to provide some insights about this emergent form of distributed participatory design and to characterize to which extent the participation of users in OSS communities guarantee their needs to be taken into account. After of presentation of Python, the community we focus on, and of our methodological approach, we will synthesize our research contributions around three points:

- The design activity in OSS is mostly oriented toward peer reviewing through evaluative activities.
- The design discussions are framed and boosted by key participants.
- The participation of users: users-pushed design proposals can succeed only under some conditions, and users activity is not only informing design and they are not the sole providers of knowledge regarding their needs and usages.

PYTHON COMMUNITY: FOCUS OF OUR STUDY AND METHODOLOGICAL APPROACH

Python and the PEP design discussions

We focus on the Python community. The designers of Python (a programming language) engage in a specific design process called Python Enhancement Proposal (PEP) as the main means for proposing new features and collecting community input on a design issue. PEP is quite similar to two design processes used in conventional software projects: Request For Comments (RFCs) and technical review meetings [1]. PEPs are discussed in the mailing-lists of Python (python-list, the general mailing-list and python-dev, the mailing-list for Python developers). All these discussions are archives and publicly available and constitute relevant traces of the design process, as the major part of the design occurs in this discussion space [8].

Users' role and statuses in OSS community

The literature on OSSD identify clearly, on one hand, the role of active users participating in the evaluation phase of design (bug reporting and patching, new modules proposals, e.g. [10]) and, on the other hand, the role of the project leader, administrators and developers of an OSS projects in the proper design process, that is to say their participations in generating, evaluating solutions and in taking decisions [2]. An open issue is still to characterize the role and participation of users regarding the proper design and the design decisions.

Combination of structural and content analyses

Our methodological approach combines structural analyses of online discussions (organization of messages into discussion graphs based on quoting, i.e. who is quoting who in online discussions, cross participation and organization of parallel discussions) and content analysis of messages based on a coding scheme which distinguishes activity-related categories reflecting the functions of a turn in the design discussion (e.g. making a proposal), from reference-related categories reflecting the knowledge which is shared (e.g. knowledge about use).

DESIGN ACTIVITY ORIENTED TOWARD PEER REVIEWING

Our content analysis of the messages in PEPs discussions [2] revealed that evaluation is the activity mostly performed by all participants (including users), enhancing the peer reviewing form of design. We found lower frequencies for activities such as clarification and design proposals. The clarification activity, less frequent than in face-to-face design meetings ([1] [9]) is framed by the project leader and reserved to specific locations in the online discussion space.

DESIGN DISCUSSION FRAMED BY KEY PARTICIPANTS

Our structural analysis of the messages in PEPs discussions [3] revealed links between the organized social structure of the Python project and the shape of the discussion space. A participant's assigned role in the project organization affects its quotation rate and, therefore, influenced the unfolding of the design process within the discussion space. Key participants led and ensured the thematic continuity of the PEP online discussions we studied: the project leader or an administrator relaying him, and the champion (proponent) of the PEP, who can be a user. They tend to be more quoted than other participants; the champion is the main provider of synthesis activities, boosting this way the community; and the project leader often close sub-thematic discussions or thematic drift.

DESIGN ACTIVITY AS A SPECIFIC FORM OF PARTICIPATORY DESIGN

Our ongoing research on a "pushed-by-users" design proposal (PEP 327) reveals cross-participants that act as boundary spanners between users and developers [7]. We define Cross-Participants (CP) as persons who participate at same-topic discussions, occurring in parallel mailing-lists at the same time (extended notion of cross-posters [6]).

To identify CP, we organise all discussions occurring in python-dev list (developers-oriented list) and python-list (users-oriented list) about PEP 327 in a temporal view (Figure 1). The python-dev and the python-list discussions about this PEP are represented in parallel. Cross-participation between parallel same-topic discussions in python-list and python-dev is labeled using dotted vertical lines. The analysis of the temporal organization of the PEP process helps us to select 5 discussions occurring in parallel in the two mailing-lists and were cross-participants appeared[1], among the 52 discussions. 4 out of the 5 discussions are at the beginning of the design process. To characterize cross-participants (CP), we first identified all the posters in these discussions. They are identified according to their status: project leader (PL); administrators (A), developers (D), the user-champion (U-C) and other users. We call users those that are not clearly identified as administrators or developers on the project webpage. 5 people were identified as participating to parallel same-topic discussion: the user-champion (he was not formally define as a developer at the beginning of the process and was the project leader of a financial project), 1 administrator who is known as an expert of the decimal domain; 2 developers, of which one had already worked on a decimal module; and 1 user.

To characterize more finely the role of CP and other participants in this design process, we combine a structural analysis of quoting links between messages and a content analysis of messages.

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[1] Each discussion is labeled using its subject on the online archives. For a more precise description of the temporal organisation of the PEP process, please refer to [11]

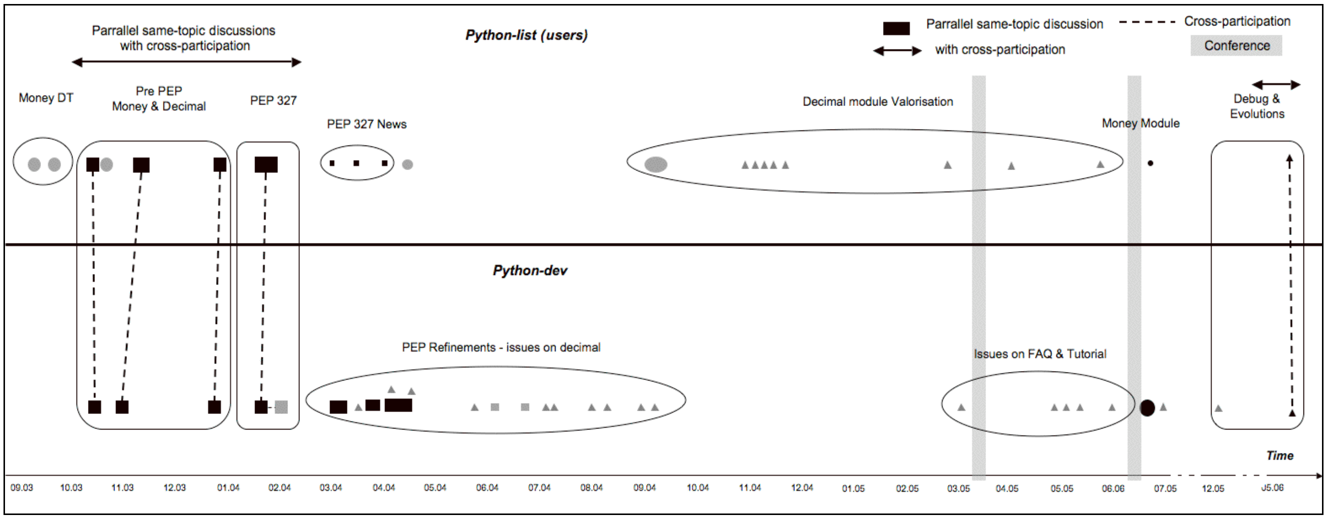

Figure 1. Temporal view of the PEP 327 discussions in a developers-oriented list (python-dev) and a users-oriented list (python-list)

The attraction graph[2] in Figure 2 represents who tends to quote who in both python-list and python-dev. It outlines that CPs tend to be the link between the users community (U) and the developers community (A-D and PL) with a specific position for the user-champion (U-C, who is also a CP) who quotes and is quoted more by the project leader (PL) and the administrators-developers (A-D) ,i.e. the developers community.

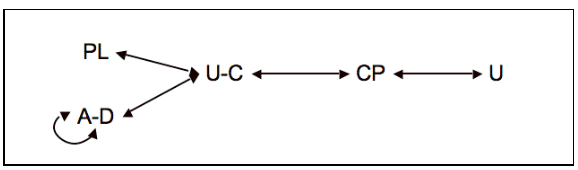

Figure 2. Attraction graph representing who tends to quote whom in the discussions

Our analysis of messages content (activities and references/knowledge sharing) highlights that CP (identified by a structural analysis) provide knowledge about both the user-oriented application domain and the developer-oriented programming domain: this way, they cross the boundaries between users and developers communities acting as boundary spanners. Being the main providers of knowledge about use in both users and developers communities they also maintain a strong focus on usage. The user championing the PEP is a key CP enhancing harmonious social relationships referring to other persons works, and a coordination agent doing synthesis and posting news about the design process in mailing-lists.

Finally, users do not refer more to use than other participants. The design-use mediation is rather supported by the boundary spanners who are not necessarily users (2 users and 3 administrators or developers). The boundary-spanners role seems to emerge in the collective activities based on technical, discursive skills and interest of participants.

DISCUSSION AND PERSPECTIVES

Our work provides insights on an emergent form of distributed participatory design in OSSD. An important result concerns key roles played in this distributed process, the cross-participants that relay and support users participation. An open issue is still to characterize necessary conditions and barriers for a design to be, or not, participatory.

Our contribution is also methodological. Considering the large quantity of data in OSS communities it is tempting, and it is often the case, to use only structural analyses such as social network analysis to characterize OSS design process. We have attempted to illustrate that the combination of structural and content analyses of online discussions is essential to capture the richness and the complexity of the OSSD process.

ACKNOWLEDGEMENTS

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[2] This graph is based on the relative deviation (RD) analysis. RDs measure the association between two nominal variables. They are calculated on the basis of a comparison between observed and expected frequencies (i.e. those that would have been obtained if there was no association between the two variables). There is attraction when the RD is positive, and repulsion – when it is negative. By convention, we reported only attractions with values >.20.

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Design Methodology is not Design Science

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ABSTRACT
This paper argues that design methodology cannot become the science of design. A method does not constitute a science. Moreover, in the same way that biology is not a science of how biologists work, design science cannot be a science of how designers work.

Author Keywords
Design, science, methodology

ACM Classification Keywords
H5.0. Information interfaces and presentation (e.g., HCI): General.

INTRODUCTION
It is custom to submit papers to workshops that support the fundamental ideas of the workshop. When I read about the "Converging on a Science of Design through the Synthesis of Design Methodologies" workshop I felt obliged to do the opposite. In this paper I will challenge the goal of this workshop to converge on a science of the design through converging of design methodologies. This will probably raise the eyebrows of the organizers and maybe also of the workshop participants. However, it is the nature of science that truth remains truth, independently of what people think of it. This quest for truth is fueled through dialectic discussion and I hope that this manuscript will spark an open dialogue about the goal and status of design in the HCI community.

DISCUSSION
Besides the workshop title, the description also states that the workshop will focus on design methodology and that it will "make a contribution to the establishment of design as a science." While the definition of a design science is a noble goal, the method chosen appears flawed. Science consists of a method to observer and abstract reality into models that are then used to explain and predict reality (see Figure 1). Newton's law of gravity, for example, explains why an apple hit Isaac Newton and it also helps us to predict the position of the planets in the future. The various sciences claim certain parts of reality as their phenomena under investigation.

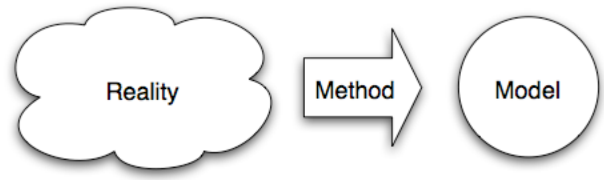

Figure 1: scientific process

The method of science is to some degree universal and is often referred to as the 'scientific method'. The scientific method is a body of techniques for investigating phenomena and acquiring new knowledge, as well as for correcting and integrating previous knowledge. It is based on gathering observable, empirical, measurable evidence, subject to the principles of reasoning. Chalmer (1999) provides a fair discussion of the scientific method. However, a methodology in itself can never constitute a science. Lets take the example of the dissection method. Biologists may use dissection to analyze animals, but also butchers use it to cut steaks. The method is the same, but one results in scientific knowledge, while the other in a delicious meal. Moreover, in the same way that biology is not a science of how biologists work, design science cannot be a science of how designers work. Even converging on a specific design method cannot overcome this conceptual limitation. Again: a method does not constitute a science and design methodology cannot be the phenomena of design science. The goal of the workshop to create a design science cannot be achieved by converging on a design method.

The sciences distinguish themselves not through their methods, but through the phenomena they investigate. Biology, for example, is the science of living organisms. What a design science is primarily missing is a phenomenon. The problem becomes clearer when we consider that design's prime objective lays in the intersection between artifacts and users (see Figure 2). Designers contribute to the creation of artifacts that interact with humans.

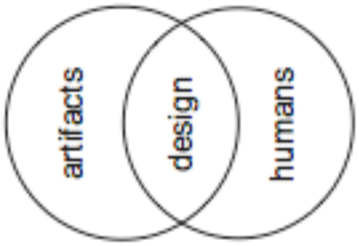

Figure 2: Framework of Design

Everything there is to know about the artifact (left side Figure 2) is available from its manufacturer. All its dimensions, material properties and functions are known. The artifacts are therefore not good phenomena to investigate. The creation of new materials and operational principles has also already been claimed by engineering and physics. Engineers also discussed rational design methodology that heavily relies on mathematics (Alexander, 1964; Simon, 1996; Vincenti, 1990). Interestingly, these rational design methodologies have not been included in the description of the workshop even though the have one fundamental characteristic that brings them closer to science: the results produced through these methods are objective. This means that the results are independent of the designer who applies them. This independence is a major step forward into the direction of generizability.

On the other side (right side Figure 2), understanding humans is the prime objective of medicine, anthropology and psychology. Design science would have difficulties competing. Even "Design methodology", or to be more general, "human problem solving", has already been treated as a phenomena investigated by psychologist (Dorfman, Shames, & Kihlstrom, 1996; Feist, 1994).

As we can see, both, artifacts and humans have been claimed as phenomena by physics, engineering, psychology and medicine. The definition of a design phenomenon is possibly the most urgent step in the development of a design science.

When we take a look the body of scientific knowledge, it has been engineers again that attempted to create a consistent and logical body of knowledge (Hubka & Eder, 1996; Vincenti, 1990). As we can see, the arena of design science is filled with actors and it one may ask then why the designers in the HCI community are so keen on turning design into a science? Design has been criticized by the academic section of the HCI community to be non-scientific. An example of this conflict occurred at the 2005 SIGCHI membership meeting. The organization of the CHI2006 was discussed, which ignited a shouting match between academics and practitioners (Arnowitz & Dykstra-Erickson, 2005). Both groups defended their access to the conference through the different publication formats, such as papers sessions, panels, and case studies. At the conference itself the conflict reoccurred in the "Design: Creative and Historical Perspectives" session. Paul Dourish took the role of defending the science of ethnography against its degradation to a service provided to designers (Dourish, 2006). Next, Tracee Verring Wolf and Jennifer Rode defended creative design against the scientific criticism by referring to design rigor (Wolf , Rode, Sussman, & Kellogg, 2006). Both groups felt the need to defend themselves, which indicated that both had the feeling of being under attack. Trying to defend design by claiming that it is scientific may appear to be a good respond to the academic criticism, and designers are naturally attracted by the quality label of science. Chalmer (1999) pointed out that:

Science is highly esteemed. Apparently it is a widely held belief that there is something special about science and its methods. The naming of some claim or line of reasoning or piece of research "scientific" id done in a way that is intended to imply some kind or merit or special kind of reliability.

It is a noble goal to create good and reliable design, but this may not be achieved by using the scientific method and neither may the claim of a design science be a good response to the academic criticism. Not everything has to be scientific and designers are playing an important role in the creation of artifacts. They should be proud of the role they play in the HCI community. Discussions on design methodology are a good step forward to further improve design practice. A CHI workshop is a good forum for such a discussion. However, for reasons explained above, it may not be wise to claim that this would lead to a design science. A possible better name for the workshop might have been "Converging on Good Design through the Synthesis of Design Methodologies".

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User Experience Building Blocks - Reducing Design to Content Filling

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ABSTRACT
Design methods are usually described and evaluated with focus on user-centricity and potential for innovation. This paper discusses design processes with respect to scalability and repeatability.

Categories and Subject Descriptors
Human Computer Interaction, User Experience, Design Process.

General Terms
Design, Human Factors.

1. INTRODUCTION
For large software vendors and provider of platforms, the costs of designing new solutions on top of a platform or extending or adapting existing solutions to vertical markets and specific customer needs have to be considered. Different strategies have been implemented to solve this problem

1.1 UI Standards
One common approach for reducing costs of design is to define and distribute design standards that describe re-use components and generic page layout. While the main purpose of such standards often is to enforce consistency across screens and applications, UI standards also speed up design by providing a basic rule set of how to layout the screen and functions.

But this is only true for the experienced designer who is familiar with UI standards, and who is apply such rules when creating a new application design. UI standards are, as the name already implies, usually very UI centric and only provide limited hints on when to use them for what user requirement.

While UI standards may speed up the detailed user interface design, they generally do not provide much guidance on what requirements to collect and how to map requirements to a good design.

1.2 UI Patterns
With service-oriented technology and modern front end technologies, user interfaces can be built based on re-usable pattern components. After the pattern has been designed and implemented once, it can be re-used within or across applications by linking it to different data sources or by modifying the configuration. For example, a list of work orders for service technicians and a list of approval requests for line managers can be implemented using the same inbox pattern and linking it to different sets of work items and offering different related actions.

UI patterns have been primarily introduced to accelerate software development by shifting from a coding to a configuration paradigm. When assembling a pattern based application, designers must be able to map an usage scenario to the closest available pattern and configure the pattern in a way that it supports the targeted use case. Patterns are perceived as very helpful if they match the user requirements, but also very restricting if they limit creativity and constrain the design.

Academic research on design methods does usually not differentiate between free style design and pattern-based design, because pattern-based design is typically a proprietary approach specific to one platform or vendor.

In the following sections I want to argue that the potential of UI patterns can be extended beyond the technical re-use aspect if they are described as design building blocks that guide requirements gathering and reduce the design process to content filling.

2. User Experience Building Blocks
User Experience building blocks describe, similar to UI pattern, re-usable components of an application, but instead of just describing UI, they are focused on the underlying work practice of users [1]. Such design building blocks carry much more semantic than UI description and serve as templates for re-occurring usage patterns instead of re-usable UI components only.

2.1 Guidance for Construction
Before a designers details out the user interface, it is best design practice to first layout the application structure and decide upon the information architecture of the application.

In scenario-based design, task flow models are used to identify the required interaction steps and to come up with a screen flow that supports each usage scenario. While storyboarding such interaction sequences, the designer defines screens that support the steps within the task flow. Another way of capturing such interaction sequences in a more abstract form is to write use cases and specify the system input and output required for each interaction step.

Interestingly, this process does ignore one very prominent design metaphor which is the concept of places. A good software application design is centered around meaningful information places from which the use may initiate certain actions.

For example, in an online shopping product, it is obvious that there will be a place for browsing products, a place to review the shopping cart and to check out, and maybe a place for setting personal preferences and maintaining profile data. One concrete shopping usage scenario would cross the catalog and the shopping cart place, but would not necessarily identify such places as key information places, but only as screens required for this specific task flow.

While playing with some core usage scenarios, the main design focus is on identifying the appropriate places that reflect generic user intents and bundle information in a meaningful way. Once identified, the scenarios are again used to benchmark the resulting navigation within and between places.

As we can see, the process of finding an application structure is relying on the dualism between testing flow and, at the same time, establishing places. One design method which offers an explicit design step and notation for describing the application structure independent of the actual user interface is the User Environment within Contextual Design [2]. The User Environment introduces a concept of focus areas which represent information clusters. Such focus areas can be used to describe and specify information places in a non-UIish way and also add links between such focus areas to support concrete usage scenarios.

While visually oriented designers sometimes perform this step with UI scetches, others have strong preferences for the User Environment method and maintaining their entire application structure is such an abstract notation. In case of multi-channel applications, in which a focus area may map to different user interfaces depending on the target device, UI independent representations of an application become a key asset in the design.

User Experience Building Blocks can be considered as specialized focus areas tailored for a specific work practice. For example, a toolset to build online shopping solutions could offer User Experience building blocks for shopping in a catalogue, a shopping cart, and for a personal profile. Each of such templates would resemble focus areas with some pre-defined semantic tailored to the purpose of this building block.

As the purpose of an User Experience Building Block is known a-priori, it can provide suggestions about functionality and content. It could, for example, suggest functions for browsing and collecting multiple products in the catalogue, or changing quantities in the shopping cart when checking out.

Designing based on User Experience Building Blocks is like working with a pre-defined abstract User Environment tailored to a certain task domain. The construction of an application is much faster when templates of building blocks are available. The designer only has to fill in the information and functions specific to the use case.

2.2 Guidance for Discovery

As User Experience Building Blocks abstract common work practice, they can also be used to guide user research and set focus in the contextual interviews.

As described in Contextual Design, the focus setting before the contextual interview is very important as it influences what you discover in the field. When interviewing or observing the work practice of end users, the interviewer will only capture those facts which he or she is focusing on. If you are focused on people to people collaboration, you might capture every communication between people, but may not notice how users organize their personal work or do other job related tasks.

User Experience Building Blocks can train interviewers to focus on certain aspects [3]. Once interviewers discover an opportunity to apply a building block (for example observing a shopping scenario might set the focus on validating the appropriateness of the catalogue and shopping cart functionality. Such design building blocks activate a set of design hypothesis which can used to be validated in the interview or used as a heuristic tool to guide the interview to complementing information.

3. Deconstructing design

Defining a design process based on User Experience Building Blocks allows for targeted requirements gathering and, in the extreme, reduces the design process to content filling. Solution architects would capture content and functions within specialized templates. In [?] we gave examples of Context Maps that are used to capture information for building blocks used in composite business applications.

If pre-implemented UI patterns are available for the User Experience Building Blocks, the capturing of requirements could be potentially done directly within the target user interface, either on paper or per wysiwyg editor to get feedback not only on concepts or ideas, but on UI samples. End users can usually not articulate their needs, but respond to sample UI very directly.

Apple's iWeb is such a tool for creating web pages by selecting an appearance (colors, border decoration, fonts) and specific page type templates (layouts). These are pre-populated with placeholder content (text, images, links) which the user replaces by copy-paste, drag-and-drop, importing or simply pointing to a page to be linked to on click. So right from the beginning there is a web page which can be viewed in a browser and navigated, but then can be progressively modified, first with own content, then by connecting pages, then by tweaking various appearance aspects, like changing the font size or background color.

This is a good example of end user development [4] in which the expertise of design is not required and the user is enabled to develop a web site without any understanding of design and underlying technology.

The potential of replacing UI design by directly mapping content to User Experience Blocks depends on the existence of patterns of work practice and predictable user intents. This is often the case in many business applications and consumer oriented web sites.

User Experience Building Blocks leverage an initial design and amortize the investment in design over many, many instances of solutions. It requires a high quality initial design based on a solid analysis and identification of patterns of work practice in the target market.

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Design Methods to Engage Individuals with Cognitive Disabilities and their Families

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ABSTRACT
In this position paper, I describe the process of adapting and combining traditional design methods to design assistive technology *with* and *for* individuals with cognitive disabilities and their family caregivers. First, I will present a research project to design a remote communication system with families with a young adult with cognitive disabilities. I will then discuss design methods that contributed to this research.

BACKGROUND
Today, many individuals with moderate cognitive disabilities live with their parents as children and young adults. When these individuals graduate from the school system, parents find themselves with the added responsibilities of acting as their grown child's primary caregiver and social coordinator, managing their child's schedule as well as their own [5]. New supports are needed for this family-based care model, such that parents feel secure and confident letting their adult children go out into the community, and know they are safely reaching their potential as active community members.

Remote communication can potentially play a dramatic role in increasing the independence of young adults with cognitive disabilities [10]. Yet there are significant HCI problems for this population with off-the-shelf mobile phones, and there is little research to understand the requirements for a remote communication system for individuals with cognitive disabilities.

RESEARCH GOAL
In this research, I co-designed a picture-based, handheld remote communication system with young adults with cognitive disabilities and their family caregivers. The system has simple mobile phone capabilities. The user sends and receives calls through a picture and audio-based interface (see Figure 1). The system also supports remote communication tasks specific to the needs of the families, and the system interface and functionality is customized for the needs of each user. The platform is a Windows Mobile 5.0 handheld phone. The goal of this research was to design an effective remote communication system for each family, and to understand the dimensions of customization that the system would need to support to become a meta-design environment, to evolve with users' needs and abilities.

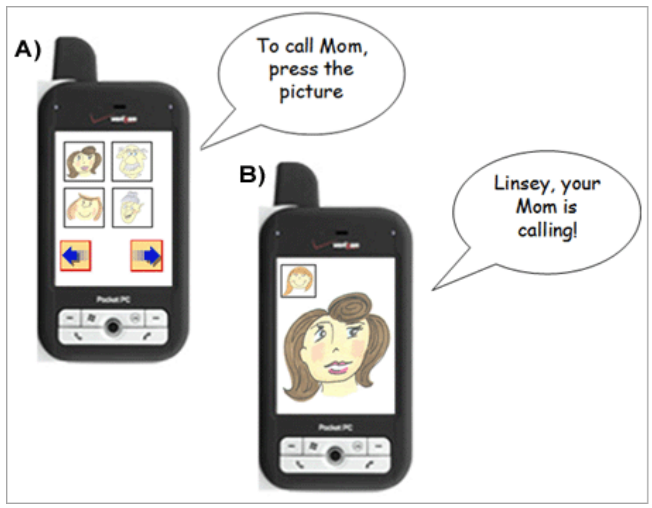

Figure 1: Remote communication system for the care recipient. A) Making a call; B) Receiving a call.

DESIGN APPROACH
This research project had three phases, with each phase progressively grounded in and building on the previous phase. I first developed an understanding of *how things are* by studying existing practices and technology in use, and then moved to exploring *how things can be* by introducing new technologies into the environment. I combined design methods including ethnography[11] , participatory design [14], and evolving technology probes [8].

The first phase was a semi-structured interview study (n=20) with parents and teachers of students with cognitive disabilities [4]. The purpose of this phase was to gain a broad understanding of the role that assistive technology plays today for these groups, and the benefits and barriers to assistive technology adoption and use. I learned about current technology that caregivers are using to provide care, and technology young adults with cognitive disabilities are using (including assistive technology, and general technology like video games and portable music players). I explored issues and barriers in assistive technology adoption that parents and teachers have experienced. Finally, I asked parents and teachers to share their hopes and dreams about assistive technology, so that my research could be guided and inspired by the visions of my user population.

In the second phase, I took a closer look at a few themes that emerged in Phase 1: remote communication, independence, and social connectedness. Phase 2 was a more in-depth semi-structured interview study with fewer participants (n=5). The research setting was the family home, and I interviewed parents and their young adult children with cognitive disabilities. I learned about ways that caregivers and care recipients achieve remote communication today, and the role that it plays in increasing independence and safety. I also explored perceptions of independence and safety, among parental caregivers as well as among young adults with cognitive disabilities. Although some of the young adults with cognitive disabilities used mobile phones and some did not, I learned about common themes in requirements and desires for an accessible mobile-phone based remote communication system.

In the third phase, I conducted an evolving technology probe study [8] with two of the participant families from Phase 2. The purpose of this phase was to understand how a handheld remote communication system can support the remote communication tasks specific to each family, and how each family's needs and requirements change over time through realistic use. In this phase I co-designed the technology probe through participatory design activities with each family. The functionality and user interface reflected the needs and abilities of the child with cognitive disabilities and the goals and practices of the families. The technology probe simultaneously supported remote communication and unobtrusively "observed" the user in communication tasks. In *probe fashion*, we also added features to the system meant to inspire and provoke families to reflect on ideas about future technology During this phase data was collected through the probe usage logging, a nightly voice-mail diary, semi-structured interviews and observations. We conducted participatory design activities during the probe study to modify and evolve the probe, and then I implemented the modifications. Evolution was based on usability problems as well as new ideas that emerged through use.

UNIQUE DESIGN ENVIRONMENT

There are three ways in which this design environment differs from a typical software design project. First, we are designing for individuals with a wide range of cognitive and physical abilities. While we strive for universal design, we must also recognize that each user represents a "universe of one" with unique needs and abilities. As a result, designers can make fewer assumptions about users' abilities and ways of interacting with technology [12]. Typical user-centered design methods like single interviews and brief observations are not sufficient to develop a good understanding of a person's skills and practices. Basic user models used for evaluating an interface must be reconsidered for users with disabilities [9]. This is complicated by the fact that these users are more challenged in describing their own situation and motivations. Often, the skills central to abstract conceptualization and reasoning are very limited, and users may be unable to conceptualize and verbalize their individual needs and preferences.

A second way in which this environment differs from a typical user-centered design scenario is that each user is represented by him or herself as well as through a network of caregivers, among whom there is distributed knowledge about the user's abilities, interests, and behaviors [2]. Caregivers also have hopes and goals for the individual with cognitive disabilities, and the motivations of the caregivers must be understood and balanced with the individual's motivations during the design process.

A third consideration for this project is that it takes place in family homes and communities, rather than the workplace. Conducting design in the home environment introduces dimensions of accessibility, privacy, dynamic and ad-hoc organization, and a more delicate environment that changes with the presence of the researcher [3, 8].

REFLECTING ON DESIGN METHODS

A carefully crafted research methodology that considered the unique aspects of the design environment was needed in this research. I will now discuss the strengths and limitations of the design methods I incorporated in the project.

Ethnography

Ethnographic methods such as in-depth semi-structured interviews, participant observation, and diary studies [1] provide the designer with rich real-world data about the user's social and cultural environment. These activities are extremely valuable to ground a design project in rich user data. Yet there are challenges using ethnographic methods in a private setting such as a family home, where a researcher can't unobtrusively observe family activities in the home for extended periods of time. Also, ethnographers frequently spend years collecting sufficient data to describe a social situation, during which time they dedicate their lives to the project and immerse themselves in the culture of study. Technology designers almost never have the time nor the inclination for such an undertaking.

Participatory Design

Participatory design empowers users as co-designers of their own technology. In my design environment, caregivers and individuals with cognitive disabilities are both vested stakeholders in the design, and have very different ways of contributing to the design process. I found that caregivers were able to contribute to typical participatory design activities (such as sketching and evaluating low-fidelity mockups) much more than individuals with cognitive disabilities. Another limitation of participatory design is that it only considers the technology system during the design phase, and doesn't address how the system must change and evolve during use time [6].

Meta-Design

Meta-design is relevant for this design environment because it can potentially help address the following issues:

- **Wide variations in user ability**. Due to the variance in individual users' abilities (for a device to be used by people with a range of cognitive disabilities), the user interface and functionality of the device will need to be customized (most likely by the family caregiver).
- **Frequent changes in communication needs**. Parents frequently update their children's augmentative communication devices based on current activities (e.g. to talk about what the individual did last weekend, etc.), and so there is reason to believe that the remote communication device may need to be frequently updated.
- **Changing usage environment**. The environment in which the communication device system will be used is far more dynamic than a workplace environment, and changes in users' abilities and environment will introduce new communication needs.

The meta-design approach recognizes that a technology system will need to change and evolve during use time according to the unique needs of different users.

When designing new technology, there is a bootstrapping problem in anticipating the nature of evolution [15] before the user has begun to use the technology. Designers need to anticipate which system modifications should be possible, and which should be easy. Since every configuration option and user interface element adds complexity, each dimension of customization must be considered judiciously. Easy modifications should be in areas of the system where the desired behavior and or appearance of the system are very likely to differ between users, and should be supported as customizations before or during use time. Possible (but less easy) modifications can be in areas where the behavior or appearance of the system are likely to be the same for most users, and so can be treated as more advanced capabilities. Some aspects of the system need to be made intentionally difficult to modify, in order to prevent accidental breakage of core functionality.

Before use, new envisioned technology will have limited meaningfulness for users, and users will thus have limited motivation to participate in design. Even when users are highly motivated, most are unable to predict and articulate their own contextual behavior before they have incorporated the technology into their lives. Figure 2 and Figure 3 illustrate these two challenges.

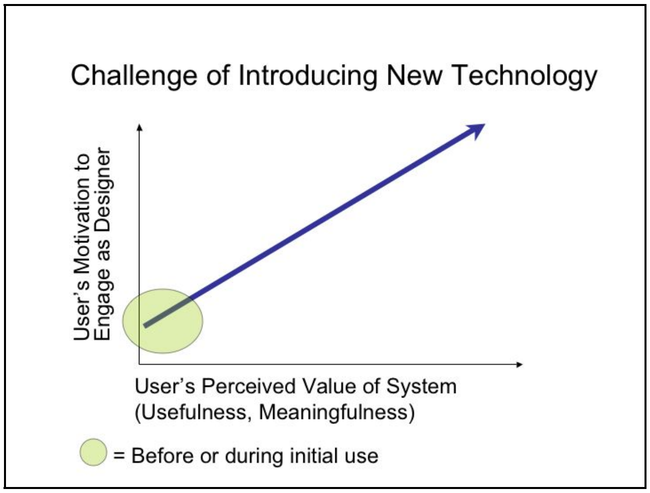

Figure 2: Risk of assuming user motivation before user has experienced value from the system

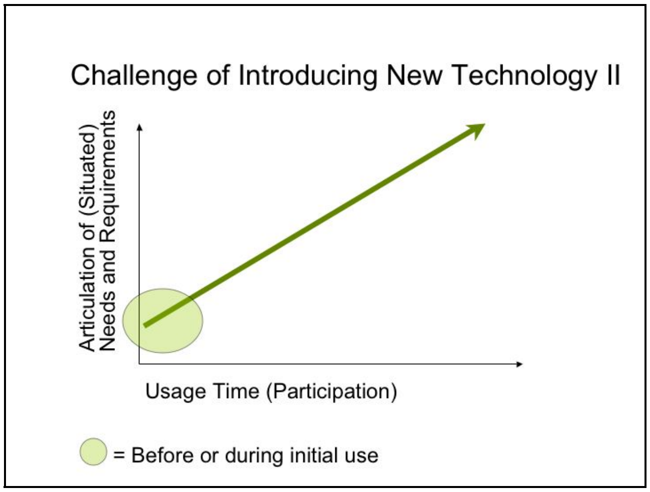

Figure 3: Challenge of anticipating situated action, and dimensions of evolution

These figures illustrate the challenge of designing a meta-design environment for new technology. In my design approach I found I could mediate these challenges by combining participatory design with technology probes, which incorporate *technology usage as part of the design process*.

Technology Probes

Technology probes [7, 8] explore a domain of human behavior by providing simple, useful functionality, inspiring users to consider how technology can enhance their environment, and collecting extensive usage data through realistic use.

Insights into Requirements for a Meta-Design Environment

Traditionally, the functionality of a technology probe does not change over the course of a study. To explore emergent customization needs, I actively modify the technology probe through participatory design activities throughout the usage study. I found that supporting an *evolving* technology probe gave insight into how users' needs change over time, and how our system could be designed as a meta-design environment.

Engaging with Individuals with Cognitive Disabilities

During the probe study, the participants with cognitive disabilities moved from passive onlookers to active participants in the design process. I hypothesize that there are at least two reasons for this: technology probes support *knowing-in-action* and *reflection-in-action* [13]; and the probe provides affordances that connect emotionally with the participants with cognitive disabilities.

Individuals with cognitive disabilities, like everyone, have a great deal of knowledge that is tacit and embedded in their actions, which makes self-reporting difficult [13]. For these individuals, this is compounded by a limited language ability and difficulty with abstract thought. Rather than asking users to describe previous usage scenarios or imagine future ones, technology probes allow users to interact directly with technology and effectively "show you" what they want and need.

Challenges

Challenges of conducting an evolving technology probe study include the intensive time requirement of a researcher during the probe study, to maintain and evolve the technology in rapid iterations. Researchers must be committed to address technology problems and requested changes rapidly in order to maintain a high level of trust and confidence by the participants. Another challenge with a technology probe is that it introduces technology into the environment fairly early, and may narrow the design space prematurely. Researchers can present various versions of modifications, or even various versions of the probe, to actively encourage participants to consider diverse design ideas.

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Learning from an Extended Context of Patterns in Science of Design

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ABSTRACT
In this position paper, we present an interdisciplinary approach to patterns and pattern languages in HCI-design. Our work is grounded on a theoretical framework, tailored for use in early design stages. It incorporates ideas from pattern methodology, Gestalt theory and visual language. As an ideal final result in the field of human-computer interaction (HCI), our work intends to establish intuitive user interfaces. Basically, we try to achieve this goal through a problem-oriented, interdisciplinary knowledge transfer by means of pattern methodology.

Author Keywords
HCI, Gestalt psychology, art, visual language, patterns, knowledge transfer.

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): theory and methods, user-centered design.

INTRODUCTION
In previous work we have introduced ideas, foundations and a conceptual framework of a descriptive pattern language based on Gestalt theory, visual language, and semiotics [5], [6]. Context can be regarded as the large family of meanings and estimations that is the basis for conscious evaluations. Human perception as well as cognition seem to be founded upon the existing (perceptual) knowledge in a particular context. During human-computer interaction (HCI), top-down processing is based upon a prior knowledge of the world. This knowledge-driven perception involves the notion that our preexisting concepts, knowledge, ideas, and anticipations influence the way a stimulus is interpreted. Knowledge presented at higher levels and intellectual abilities determine what is perceived. Since learning is based on the strengthening of associations, ideas that do not relate to existing knowledge simply cannot be learnt [8]. Therefore, when designing interactive software components, the users' cognitive processes as well as their cognitive limitations must be taken into account. As a result, the nature and causes of the problems users encounter need to be identified and explained. We believe that this could be done best with patterns and pattern languages. In contrast to documenting very specifically (technical) needs or even idioms we prefer a more general approach including also questions of *why*, rather than questions of *how* to convey interdisciplinary knowledge. Within our pattern language framework, we aim to discuss the effects of Gestalt principles and visual language components comprehensively. As examples we establish parallel notions taken from multiple disciplines, predominantly from art. Through this "chunking aside" we aim to convey symbolic qualities. Thereby, we follow a more narrative form, easy to understand by the end user in an interdisciplinary context [15]. Consequently, we try to foster a convergence of science and art.

VISUAL LANGUAGE HISTORY
First attempts of visual language as a matter of design can be found with artists. KLEE [12] and KANDINSKY [10] tried to identify an abstract and universal grammar of visual expression. KLEE'S grammar of elements involves a metaphor between visual and verbal form: the relationship between point, line, and plane is compared to active and passive "voice" in language. Later, two books by KEPES [11] and MOHOLY-NAGY [14] elaborated the theory of visual language and gave it a scientific rationale. Influenced by the Bauhaus and by Gestalt theory [13], [18], KEPES'S work, for example, verified and expanded on the notion of an autonomous faculty of visual communication. His studies also included psychological phenomena, such as figure-to-ground relationship, consequences of similarity, closure, inclusiveness, and submergence.

HORN [9] described visual language as *"the tight integration of words and visual elements and as having characteristics that distinguish it from natural languages as a separate communication tool as well as a distinctive subject of research"*. In his analysis of the properties of visual language, he uses well-established categories of linguistics: *morphology*, *syntax*, *semantics*, and *pragmatics*. Morphology involves a set of basic elements, syntax

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establishes rules for combining these elements, semantics is concerned with the meaning of combined elements, and the actual use of elements for specific communicative purposes is defined by pragmatics. Their integration creates visual language. When visual language, Gestalt principles, and pattern mining are interlinked, in our opinion something new, which is able to increase our human knowledge, can be created.

MOTIVATION: THE CHANGE OF VIEWS ON PATTERNS

CHRISTOPHER ALEXANDER is regarded as the founder of patterns and pattern languages [1], [2]. He attempted to combine the *scientific* worldview with an adequate view of *art* and *architecture* [2]. Parts of the software engineering community have enthusiastically embraced his pattern concept, amongst others, due to the book [7]. These patterns of object-oriented software provide design solutions that are concrete enough to put them immediately into practice, limited only by the imagination and skill of the pattern user. However, in the field of human-computer interaction, the community's understanding of this technology-oriented design pattern concept and its application in HCI has undergone some changes. TIDWELL pulled the work of GAMMA ET AL. and their fellows to pieces arguing "*we badly need the benefits of such a pattern language in the field of HCI design*" [17]. One reason for this clash might be that in HCI good design rather than good programming is the key to success. According to [16], resistance often comes from technology enthusiasts who rate mathematical or technical formalism as more important than psychological experimentation. As a result, arguments in favor of a user-centered approach are far too often neglected. This seems to be a universal problem that leads to the characteristics of our two brain hemispheres, right and left, characterized by many specialized functions. With our work, we aim to convey knowledge between disciplines, symbolically speaking between the brain hemispheres. In the following enumeration by [4], not yet complete, we give examples. The first feature mentioned of each pair is attributed to the right and the second one to the left brain hemisphere:

- Separation of *emotions* and *rationality*
- *Artistic abilities* and *logical thinking*
- *Holistic* and *detail-oriented* approaches
- Sensitivity to *sets* or *sequences*
- Perception of *whole melodies* or *separate notes*
- Talent for *manual creativity* or *verbal expression*
- *Spatial* and *temporal* perception

PATTERN FRAMEWORK OUTLINE

Starting with the generic or high-level pattern *Gestalt whole-parts*, we discuss the elusive and philosophical challenge of our work. We formulated the pattern in the context of systems thinking. A good *whole,* a metaphor taken from Gestalt theory, is characterized by the quality of Prägnanz or simplicity. An appropriate translation might be "easy to memorize". In addition, we describe why and under which limitations Prägnanz can be perceived. Associated with the idea of "the whole" is a principle called *emergence* [3]: The mutual interaction of a system's parts results in new characteristic features, which cannot be found as original characteristics of any of the individual parts. When a system is dissected, either physically or theoretically, its complexity on a higher system level gets destroyed.

At the next level of abstraction we have established the patterns *Gestalt Prägnanz*, *Gestalt figure & ground*, *Gestalt focal point* and *Gestalt isomorphic correspondence* (Figure 1). Because of their ability to express semantics, we assign the linguistic category *semantics* to these patterns. Moreover, the integration of verbal and visual elements is accomplished at this level. The key question of the pattern *Gestalt Prägnanz*, for example, is how to organize morphemes of a visual language to achieve "good form" or Prägnanz? The forces occurring range from perceptual factors, the capacity of our brain, the quality of visual elements, to usability concerns, and semantic aspects. The underlying Gestalt principles contribute as elementary units to the overall goodness of *perceptual grouping* and accordingly *figure-ground segregation*.

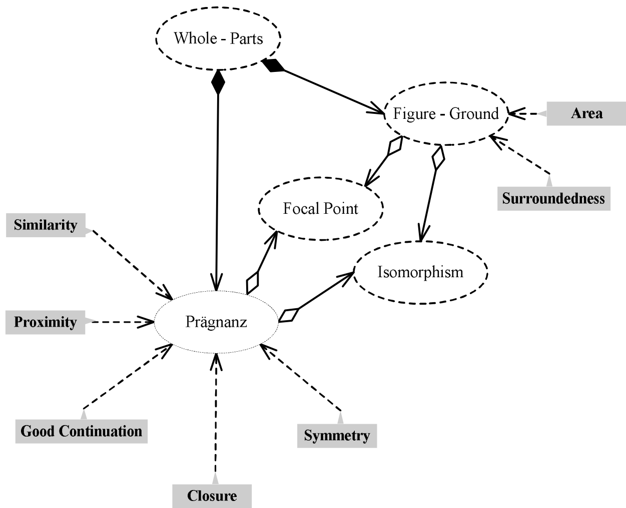

Figure 1. The proposed pattern language web.

Gestalt Principles Involved

The term *principle* is often used for referring to universal principles that describe the fundamental nature of something, for referring to universal properties and relationships between things. Principles express the most basic ideas in science, establishing a framework or methodology for problem-solving. Basically, principles should be simple, almost to the point of self-evident. A design principle, for example, is a rule to follow in design decision-making. The most common Gestalt principles and/or segregation factors state the following rules:

- Similarity – our mind groups similar things together
- Proximity – things that are close together are seen as belonging together
- Good Continuation – our mind continues a pattern even after it stops
- Closure – if something is missing, our mind adds it
- Symmetry – symmetrical images are seen as belonging together regardless of the distance
- Area – when two figures overlap, the smaller one will be regarded as the figure while the larger one will be perceived as the ground
- Surroundedness – the elements of an image seen as surrounded will be perceived as the figure, and the elements creating the surrounding will be perceived as the ground

The most basic Gestalt principles of perceptual grouping (similarity, proximity, good continuation, closure, and symmetry) as well as the segregation factors surroundedness and area state the essential findings of Gestalt psychologists in our pattern language. Through different sections, we discuss the consequences of applying these Gestalt principles. In a certain context, forces guide the reader from the problem area to the solution area. Consequences summarize the pros and cons based on the proposed solution. As we believe, these principles correspond to the category syntax in visual language.

Finally, let us have a closer look at the Gestalt principle *symmetry* or balance, which is one of the basic Gestalt principles: Morphological elements and Gestalt phenomena show signs of symmetry and a lack of symmetry at the same time. While a thing is symmetric in one or more aspects, it is asymmetric in others. On the one hand, there is no perfect symmetry in the sense that all properties are preserved; on the other hand, there neither is perfect asymmetry in the sense that no property is preserved. A very symmetric scene might be boring; a very asymmetric scene would be ugly. Formal symmetries can be found in many things – from molecules and crystals to (architectural) design and artwork.

Thumbnail of a Pattern Proposal

Within this section, we provide an excerpt of the pattern proposal *Gestalt figure & ground*.

Archetype. Every pattern should benefit from an original model, an ideal example of a type – an archetype. Most often, this is a representative picture. We made use of an artist's work, resembling real-world entities in the context of figure and ground.

Context. Generally, user interface designers are required to stimulate creative and analytic thought. In particular, they have to deal with a clear differentiation between an object (figure) and its background (ground).

Problem. The key question of the pattern *Gestalt figure & ground*, for example, is how the selective attention between figure (foreground) and ground (background) can be supported best? Forces are the cognitive background, multi-stability, properties, semantic activation and others.

Solution (excerpt corresponding to properties). A picture without emphasis is like wallpaper; the eye has no particular place to look at and no reward for having tried. Similarly, pictures which are uniformly light appear drab and lifeless. By determining the quantity, placement and intensities of morphological elements, the designer directs the viewer's attention by giving them something interesting to look at, but without overwhelming them by providing too many good things.

Different *properties* of morphological elements can either support or rather hinder the user to distinguish between figure and background. Therefore, we can depict the following characteristics:

- Usually, a figure has a shape and is perceived as more prominent than a less well-defined two-dimensional ground. Areas of closed shapes are more likely to be seen as the figure. The ground is usually open and shapeless;
- Objects that appear more convex are most often viewed as figures, while concave objects are viewed as background;
- Symmetrical figures tend to be viewed as figures;
- If an area has parallel contours, it is usually viewed as the figure. Our mind supplies missing information to construct a figure;
- Smaller units tend to be seen as figures against a larger background;
- An adequate contrast between figure and ground is especially important when a small or less dominant visual element, for example text, is placed against a more dominant background or image. A darker unit is more likely to be noticed as a figure in front of a brighter background than a brighter figure in front of a dark background;
- Similar elements (figure) are contrasted with dissimilar elements (ground) to give the impression of a whole;
- A spatially centered unit will rather be perceived as the figure than a peripheral one;
- Vertically or horizontally oriented areas are often viewed as the figure. A unit with a vertical or horizontal axis (centerline) is more likely to be perceived as the figure. The effect of a vertical axis is stronger than that of a horizontal axis;
- In rivalry, also brightness, contrast, and spatial frequency content can serve to strongly influence the balance of dominance and suppression;
- The most salient cognitive feature will be perceived as the figure.

Consequences (excerpt).

- If each part of a visual scene is provided with appropriate features, it will be easy to distinguish prominent areas (figures) from ground (background).
- Even though perception may alternate between two possible interpretations, the parts of the illustration are constant. This idea supports the Gestalt position that the whole is not solely determined by its parts.
- The interpretation of what the figure and what the ground is depends on the individual and is therefore never objective, because people have different memories and experiences that influence their perception of images.

Example. Prominent rhythmic and melodic ideas are heard as *figure on ground*. The performing medium and texture are elements of this ground, helping to establish an environment that influences the meaning of the figure. Changes in this ground often support basic changes in the pattern and structure of a composition – the form of the composition. The textural map of a composition is an aspect of its form. J.S. BACH'S "Two-Part Invention" is an example for polyphonic texture. In contrast to homophony, emphasis is placed upon the interplay between lines rather than on a single melody or a stream of chord sounds. The interplay of contour, motives, continuity features, and rhythms are important factors in polyphonic texture.

DISCUSSION

By combining pattern methodology, psychological findings based on Gestalt theory, and visual language we have established a theoretical framework, intended to convey knowledge between different domains. One of the most basic ideas was to bring people with different focuses closer together. By providing examples from artwork and literature, which are considered as aesthetical ideals, we try to give answers to questions of *why* and put them in the context of Gestalt psychology and design rationale. Within this architecture of words, symbols, and perception, the mutual relationships will emphasize the role of intuition and creativity in science of design. The current state of this work is an experimental one. Compared to the process of innovation, we are in the early stages of generating and accepting ideas. The workshop participants are invited to judge if and under which conditions some of these ideas can be accepted.

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Design of Visual Interactive Systems: a Multi-Facet Methodology

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ABSTRACT

The paper presents a multi-facet methodology for interactive software creation which melts holistic, participatory, meta-design approaches to obtain usable, co-evolutive domain specific applications. The proposed methodology is based on the definition of three Interaction Languages, each one permitting to express the conceptual model of a Visual Interactive System in the system of signs of the stakeholder (Software Engineering expert, Human-Computer Interaction expert and domain expert) participating in the design.

Author Keywords

Participatory design, Holistic design, Meta-design, Interaction Language, Visual Language, Communication gap, Co-evolution.

ACM Classification Keywords

H.5.2 Information interfaces and presentation (e.g., HCI): User Interfaces - Theory and methods

INTRODUCTION

In the last years, software engineers are increasingly required to design and develop interactive systems that are understandable, acceptable and usable by end users and that adequately support them in performing their activities in a real context, meeting their expectations, and smoothly augmenting their capabilities. The design of such systems is a complex design problem that overcomes the knowledge of a single discipline and depends on the end user culture, on the context in which the system is used and on the task to be performed.

As a contribution to the emergence of a Science of Design, this paper presents a holistic, participatory, meta-design methodology for the creation of usable, co-evolutive and domain specific interactive applications, which aims at satisfying these needs. The methodology stems from several experiences in the development of domain-specific interactive environments [6,7,19]. It is aimed at overcoming some of the phenomena affecting interactive system development, namely the communication gap among designers and users [2,5,14,17,18], and the co-evolution of systems and users [3,8,21]. The methodology we propose is *holistic* in that it takes into account the whole system constituted by the human user and the software application in use, considered as a deputy of the designer [9]. Moreover, it focuses strongly on the visual appearance of the interface and its behaviour, as it is perceived by the users [22], but it also insists on the existence of multiple interpretations of the visual appearance. The methodology is *participatory* [23] in that representatives of the users (called domain experts) participate in the design of the system collaborating with Software Engineering (SE) and Human-Computer Interaction (HCI) experts. It is a *meta-design* methodology in that design environments are provided to designers of different cultures permitting them to create and shape application environments from their points of view [7,11,12].

According to our methodology, the design process is performed by an interdisciplinary team including different experts – SE, HCI and domain experts – each expert being a stakeholder that evaluates the system and proposes solutions from his/her perspective. However, communication gaps arise among the different stakeholders participating in the design because of their different cultural background, experience and view of the problems at hand [14,17]: SE, HCI and domain experts adopt different approaches to abstraction and follow different reasoning strategies to modeling, performing and documenting the tasks to be carried out in a given application domain; additionally, each of them expresses and describes such tasks adopting his/her own language and jargon.

To overcome these communication gaps, the methodology is *multi-facet* in that it allows every stakeholder involved in the design process to reason on the problems of the system from the perspective of his/her own culture. This is analogous to an observer looking at a light beam with colored glasses which only permit the perception of one spectral component of the light: in this sense, our methodology provides each stakeholder with adequate "cultural glasses". In other words, as a prism that allows a beam of light to break itself up into its component spectral colors, our methodology breaks the interaction process into different perspectives and allows each stakeholder to observe the whole system according to his/her cultural abilities. In this way, the conceptual model of the interactive system can be expressed in each stakeholder system of signs [10].

Based on this view, we have proposed in [6,7] the Software Shaping Workshop approach to provide each stakeholder with an interactive environment allowing him/her to reason within his/her system of signs and within his/her context of work. These environments are organized in a network so that the different stakeholders can communicate each other their findings. In this way, the approach allows to relate the different perspectives to permit the synthesis of the whole process.

In this paper we focus on the description of the linguistic facets of the interaction process and their relationships, while the details of the development and organization of the software environments can be found in [6,7].

OVERVIEW OF THE METHODOLOGY

The methodology we propose in this position paper consists of the definition of three Interaction Languages – the *Interaction Trace Language*, the *Direct Manipulation Language* and the *Finite State Machine-Interaction Language* - for describing the behaviour of a Visual Interactive System (VIS for short) to each different community of stakeholders – SE, HCI and domain experts. VIS behaviour is defined by describing VIS evolution during the interaction process. Stakeholders from each community describe such evolution according to their own "cultural glasses".

Each Interaction Language defined in the methodology is based on a Visual Language. The term "Interaction Language" denotes here a language whose sentences provide an explicit description of the interaction process between the user and the VIS, whereas by the term "Visual Language" we refer to a language whose sentences are visual entities to be used in communications among humans, in human reasoning and in human-computer interaction [1,20]. These languages are the tools by which each member in the design team belonging to a specific community expresses his/her reasoning on VIS requirements, problems and solutions according to his/her points of view and to his/her cultural and linguistic background.

The proposed methodology also foresees the study of the relationships among the above languages and the definition of adequate translation methods.

The three Interaction Languages rely on a common interaction model describing a VIS in terms of its component entities, referred to as *virtual entities* (ves) [6]. This interaction model evolves and refines the model for WIMP (Window, Icon, Menu, Pointer) interaction proposed in [4]: it models the HCI process as a cyclic process, in which the user and the interactive system communicate by materializing and interpreting a sequence of messages. Users interpret the messages by applying human cognitive criteria, while the system applies criteria embedded in an underlying program P. In WIMP interaction, the messages exchanged between the user and the interactive system are the entire images represented on the computer screen, formed by texts, pictures, icons, etc. Humans look at the screen and interpret the visual message - the image - currently shown by the computer within the context of their activity, by recognizing *characteristic structures*, css, i.e., sets of pixels representing functional or perceptual units for the humans. On the machine side, each cs is the physical manifestation of a virtual entity, which exists because the computer interprets a program P specifying its appearance and behaviour.

The VIS is a virtual entity itself composed by other virtual entities interacting each other and with the user through the I/O devices. The user sees the VIS as a whole ve, whose computational state is materialized at each instant as an image i on the screen. This association between the VIS materialization and its computational meaning is called *visual sentence* (vs) [4] and specifies the state of the whole VIS at each instant.

Users interpret a cs of a component ve of the VIS, such as a selected menu, within the image i on the screen and manifest their intention to the VIS by performing an action on the cs through the input devices available in the computer at hand, i.e., clicking on the mouse button when the mouse pointer is over the cs. The VIS reacts by changing its state, i.e., moving to a new visual sentence which manifests itself to the users as a new image on the screen. More details about virtual entity theory can be found in [4,13].

A MULTI-FACET SPECIFICATION OF THE VIS BEHAVIOR

Let us examine the three Interaction Languages to highlight the linguistic facets of the interaction process with respect to the different stakeholders' culture.

The Interaction Trace Language (ITL) is specified for domain experts: it is the set of the *interaction traces*, defined as sequences of the form: initial image i_0 followed by a finite sequence of pairs <action, new image>. ITL is specified by the pair <i_0,VCL>, where i_0 is the initial image associated with the initial state of the VIS and VCL (Visual Command Language) is a finite set of *visual commands*. A visual command expresses through visual and textual expressions familiar to end users how the user has to interact with the VIS to execute a task and how the VIS visually reacts. VCL is a Visual Language based on a Pictorial Language (PL), whose sentences are the images the user sees on the screen and reasons about during the interaction.

The Direct Manipulation Language (DML), which is specified for HCI experts, describes the same interaction process specified by ITL, by maintaining explicit the visual part of the interaction process, but explicitly using VIS states and direct manipulation user actions. It is the set of the *interaction process instances*, defined as sequences of the form: initial visual sentence vs_0 followed by a finite sequence of pairs <action, new visual sentence>. DML is specified by the pair <vs_0,TR>, where vs_0 is the initial state of the VIS and TR is a set of *transformation rules* - the Visual Language of the transformation rules [5,13], based on the same PL introduced above. A transformation rule describes, at a high level of abstraction, the process through which a visual sentence is transformed into another one as a reaction to a user action. In other words, given a transformation rule, its application to a visual sentence vs_1 results in a *transformation* of vs_1 into another visual sentence, let's say vs_2, as the reaction to a user action. With respect to a visual command, which describes the interaction with the VIS to execute a given task, the correspondent transformation rule also includes a computational part specified through an adequate description of the state of the programs generating the ves composing the VIS, which depends on the adopted programming technique. DML shares with ITL the pictorial part, in that both their specifications (based on TR and VCL, respectively) are built on the same PL of the images appearing on the screen.

Finally, the third Interaction Language, the Finite State Machine-Interaction Language (FSM-IL), is the set of the possible *interaction paths* that can be performed on the Finite State Machine (FSM) recognizing the DML sentences, which start from the initial state corresponding to the initial visual sentence of the VIS. Such FSM is specified by SE experts through a further Visual Language, the State-Chart Language (SCL) [15,16]. The next state function and the output function of the FSM are specified through the transformation rules in TR. Being specified on the basis of TR, also FSM-IL sentences are built on the same PL on which ITL and DML are based.

A UNIFIED VIEW OF THE INTERACTION PROCESS

The three Interaction Languages are not independent: the set of such specifications links the user views and jargons to the SE and HCI views and jargons (and vice versa) and bridges the communication gaps arising in the design process, thus allowing the three different stakeholder communities to discuss, test and use the VIS according to their specific cultures. The three languages share the same PL of the pictorial elements appearing on the screen, which constitute the boundary objects on which each stakeholder in the design team reasons and which s/he interprets according to his/her own semantics.

Figure 1 shows the three Interaction Languages we have defined and the relationships among them. A stakeholder uses his/her own language to describe and reason on the VIS behaviour; s/he uses the different procedures to communicate his/her findings to the other stakeholders or to receive their observations.

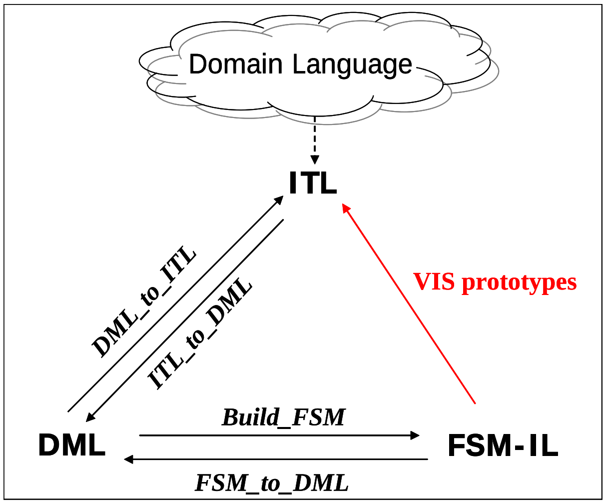

Figure 1. The relationships among the three Interaction Languages

The Interaction Trace Language is derived from the end users domain-specific language. Domain experts use it to describe the system behaviour in accordance with the user perspective. Domain experts communicate their findings to HCI experts feeding their sentences in this language. A procedure *ITL_to_DML* has been defined, which translates these sentences into DML sentences. During this translation activity, ambiguities and non deterministic definition of ITL can be found. Therefore, HCI experts may decide to go back to the ITL definition, and thus to its specification through VCL, and, with the help of domain experts, revise it in order to remove these faults. In this case, they follow procedure *DML_to_ITL,* defined to translate DML sentences into ITL sentences. In this way, domain experts always reason on ITL sentences while HCI experts always reason on DML sentences. HCI experts can additionally communicate with SE experts: algorithm *Build_FSM* has been developed to derive the FSM from DML specification and procedure *FSM_to_DML* has been defined to translate FSM-IL sentences into DML sentences, whenever SE problems emerge, such as incompleteness or faults in VIS definition, which ask for FSM revision.

The use of the three languages permits the creation of the VIS, which represents the unified view of the three perspectives on the holistic process of interaction. This is synthesized in Figure 1 by the arrow labelled "VIS prototypes" meaning that the result of the development activity according to the FSM specification is a VIS supporting users in performing some tasks in a given context.

Note that the procedures mentioned above require a certain amount of human decision-making, therefore they are not rigorous algorithms and cannot be fully automatized. The process is iterative and the developed prototypes are evolutionary [22], in that they are constructed, evaluated and evolved continually throughout the VIS life cycle. In this way, co-evolution is taken into account explicitly: each new evaluation-evolution cycle requires the revision of ITL, DML and FSM-IL. Moreover, it requires to balance the usability requests, the need of satisfying end user requests on the expressiveness of the messages and the technological constraints. More details on the three languages and their relationships can be found in [13].

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Design Informatics – Information Needs in Design

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ABSTRACT

The position I would like to advance in this workshop is that a deeper understanding for design can be obtained by taking an *information perspective* on design activities. Under this perspective the major unit of analysis is the information transaction – the specific needs and tasks associated with capturing, storing, updating, linking, and accessing information. By focusing on the information capacities that design teams create for themselves and by describing them with a technologically-neutral vocabulary, we can begin to recognize commonalities that span design methodologies. This approach offers a strategy for developing a more unified view of design which, in turn, can provide insight into the requirements of design information systems and elucidate new areas of design competency and opportunity.

Author Keywords

Design, Information Needs, Design Information Systems, Design Informatics

INTRODUCTION

Design is information intensive. In 1965, for example, Archer [1] introduced a normative, stage model of design with "data collection" at its center (Figure 1). The model shows the interpenetration or cross-connectedness of design activities and information-handling activities such as capturing relevant information, recording information in documents, organizing documents, finding documents, and seeking information from experts. When Archer introduced this model, he seemed to assume that the demands of the design process would cause information handling to unfold in a straightforward fashion.

In any case, his writing does not discuss the problematic connection between "design," that is, furthering the thing that is to exist, and "documenting," that is, recording what has been asserted or discovered about the thing. Indeed, a fundamental trade-off in all settings of design is that if time is spent documenting for uncertain future benefits, it is taken away from designing for immediate progress [8].

The costs associated with documenting can be divided into two components: 1) *Cost of knowledge* [4], that is, the costs associated with finding some information in a particular kind of system; and 2) *Cost of update* [7], that is, the costs associated with adding, updating, deleting, information that might be needed in the future. A significant long-term challenge for design, especially in the Participation Age [16], is developing an understanding for how best to manage these costs and how to weigh them against the present and future benefits of the collected information.

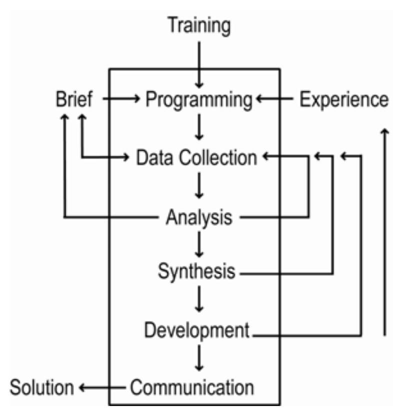

Figure 1. Information collection and flow in design (Redrawn from [1].)

DESIGN INFORMATION SYSTEMS

Design information systems, as I shall call them, are physical or electronic systems that endow teams with particular capacities for design. Because they are information systems, they also entail the costs of knowledge and update. To demonstrate these costs, consider four examples.

First, the IDEO TechBox [11] is a cabinet containing an eclectic collection of artifacts that illustrate new materials or recent innovations that can be touched and exaimed. The TechBox is intended to promote analogical reasoning and creative exploration. Because of its relatively small size, central location, and loose organization of artifacts both the costs of knowledge and update are low.

Second, the Manifesto for Agile Software Development's [3] second principle says to minimize formal documentation in favor of working systems. Consultants who teach Agile techniques often begin by eschewing electronic tools, even simple ones. Then, they introduce the use of PostIt Notes on a centrally located whiteboard, guiding the team to track very simple information – for example, features being implemented, features implemented but not tested, and features still to be prioritized, and so on. With the use of color and spatial groupings such information is readily tracked. Like the TechBox but for a different purpose, this design information system minimizes both the cost of knowledge and update; further, the system provides the team with situational awareness of the overall state of the project.

The downside of the artful use of PostIts and a whiteboard, however, is that it works for collocated teams only. To enable participation by developers who are physically remote, the team might agree to take images of the whiteboard at regular intervals and to post them on, for example, a Wiki. This move, on the one hand, provides a new capacity for involving remote participants but, on the other hand, increases the costs of the knowledge and update, perhaps significantly.

Third, Rittle's influential approach to design rationale, Issue-Based Information Systems (IBIS), appeals to the idea that systematic argumentation will enable teams to manage the complexity of an unstructured design problem. As such, when performing under the rules of IBIS, a team generates a network of linked information units, each labeled according to its rhetorical purpose. In turn, the network's function is to be a:

> *documentation and reporting system which permits fast and reliable information on the state of discourse at any time* [12, p. 4].

In this aim, we see an optimistic focus on the low cost of knowledge. Experience using IBIS, and similar systems, however, shows that the cost of update is very significant. In fact, it is often so high that the use of such systems becomes impractical [10].

Fourth, empirical studies of open source software projects [6,9,19] have described the importance of relatively simple tools and usage policies, concerning such matters as how to report bugs, how to version code, how to report code changes, and so on. In fact, the community-based model of knowledge creation [13] proposes that code versioning (e.g., stable and experimental versions) together with a discussion space (e.g., a listserv) enables a social structure to develop (e.g., Project Leader, Maintainers, Developers, and Bug Reporters). The resulting sociotechnical system enables the community to enjoy its cumulative innovations by using stable releases while simultaneously allowing it to explore, evaluate, and learn using experimental releases of the code.

In this example, we can readily recognize separate spaces for *action* and *reflection* and deictic references between the two spaces [2]. Somehow, it seems reasonable to assume, the assembly and use of the information systems that underlie open source development strike a good balance between the costs of knowledge and update. The use of mundane tools and near invisible infrastructure is striking.

In summary, these wide ranging examples illustrate an important kind of meta-design – the design of information handling systems that support the capture, organization, and use of information on which design work depends. The *cost of knowledge and update* are concepts for thinking about this kind of meta-design.

ENABLING "USER" PARTICIPATION IN DESIGN

Many approaches are currently emerging for inviting users to participate in design and development through various roles, such as the Monitored User, the Bug Reporter, the Remote Usability Participant, the Conceptual Innovator, and the Co-developer. Of course, to enact these roles and to take advantage of the information generated by them design information systems are needed.

Bug trackers, as one example, can be used to contribute structured feedback on errors [5], although pre-established labels for classifying errors, say operating system bugs, can make it difficult to submit and resolve other kinds of "errors," such as usability bug reports [17]. As a second example, Beta releases can use *discussion forums* to promote the formation of such roles as "lead users," "early adopters" and "innovators" [18, 15]. Getting into a Beta release, can garner social capital, which is then compounded when Beta participants write about their experiences in public forums and link to other Beta participants and technology commentators and culture shapers. Designers, in turn, can monitor these conversations at the periphery and develop an understanding for the users' perspectives, glean new ideas, or clarify design intuitions. Or, they may intervene directly in the forum and prompt users to talk about particular topics or share rationale on the system's evolving design.

Nevertheless, while these approaches provide the means for involving users, some significant questions arise about ends. How should the *development process* and the *artifact* under development be structured to accommodate *user-input* that is diverse and continuous? How should these three elements be interrelated? How, in short, does the network and such emerging technologies as those cited above expand the possibilities for involving users in a design and development environment and how does one select from all the possibilities? Finally, in turn, what new organizational capacities and individual design competencies are required?

Commercial slogans such as the *Participation Age* [16] and *Architecture of Participation* [14] give such questions particular urgency. The future possibility, in short, is: More people, of various roles, will participate with varying degrees of directness and influence – and most often remotely – in the development of information systems. From a position of scholarship, von Hippel [19] labels the trend *democratizing innovation* and provides evidence from a variety of domains that users are often the first to identify new needs and invent significant improvements. He argues that for commercial advantage, if not for social or ethical reasons, firms will need to structure product development to take full advantage of users' creativity and their situated adaptations of systems – but, how? As the call for this workshop asks – What are the sociotechnical conditions that lead to innovative and productive communities?

A noteworthy case for study is del.icio.us, a breakthrough application for social bookmarking. The development process for this socially oriented information management application is characteristic of open source software development in some respects and of proprietary, packaged software development in others. For example, while people are denied access to the del.icio.us source code and are prevented from running their own versions, they can use a public API to build their own applications that use the data held by del.icio.us. Then, people can discuss their innovations on a del.icio.us listserv and on public blogs. In turn, the del.icio.us development team can learn from others' development efforts and written reflections. Or, the development team can use the discussion spaces to prompt people to talk about their work in productive ways, to elicit new ideas and to discuss them, and so on. The broad picture that emerges is an intricate social network of joint reflection and the diffusion of ideas and tangible innovations (e.g., code fragments, user interfaces, etc.)

del.icio.us, in summary, shows how design and development can be *servitized*, leading to a process that proceeds simultaneously and is entwined with the formation and nurturing of a community of "users", perhaps more accurately called "innovators" [15]. And so design information systems will increase the information intensity of design as they expand the footprint of design process by allowing many more people to participate. Meta-design of this kind demands new competencies from individuals and new capacities from organizations.

THE INFORMATION PERSPECTIVE ON DESIGN

The position I would like to advance in this workshop is that a deeper understanding for design can be obtained by taking an *information perspective* on design activities. Under this perspective the major unit of analysis is the information transaction – the specific needs and tasks associated with capturing, storing, updating, linking, and accessing information. I use the term Design Informatics to refer to this perspective.

By analyzing the information needs of design and how design teams create capacities to satisfy these needs, we may begin to recognize the invariant, technologically-neutral requirements that emerge from any design methodology. In turn, we are then able to recognize the commonalities of otherwise different methodologies. An information focus, in short, offers a strategy for developing a unified view of design. I wish to defend this claim and better understand it through vigorous dialog at the workshop.

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Process and Language for Design

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ABSTRACT
In this paper, I introduce Nelson Goodman's analysis of 'worldmaking' paraphrasing it in the terms of software design, which is I think a kind of "worldmaking" activity.. Major tool we use in design are variety of languages. We must be careful about the nature of languages. In that sense, I believe we should recognize the importance of '3 dimensions and 5 patterns' principle, which was proposed by a Japanese philosopher Tominaga Nakamoto in 18th Century.

Author Keywords
Design, Process, Language

DESIGN PROCESS
In his controversial book "Ways of Worldmaking", Nelson Goodman wrote as follows:

> Countless worlds made from nothing by use of symbols – so might a satirist summarize some major themes in the work of Ernst Cassirer. These themes – the multiplicity of worlds, the speciousness of 'the given', the creative power of the understanding, the variety and formative function of symbols – are also integral to my own thinking.
>
> The many stuffs – matter, energy, waves, phenomena – that worlds are made of are made along with the worlds. But made from what? Not from nothing, after all, but *from other worlds*. Worldmaking as we know it always starts from worlds already on hand; the making is remaking. …. My interest here is rather with the processes involved in building a world out of others.

Software design is an activity to make a model of the target system to computerize out of existing non-computerized system. So, it is a kind of worldmaking (or remaking as Goodman said) activity.

About the processes involved in worldmaking, Goodman proposed following natural categorization:

- Composition and Decomposition
- Weighting
- Ordering
- Deletion and Supplementation
- Deformation

Composition and Decomposition
This is the first logical step of conceptual design. All software design consists of taking apart and putting together, often conjointly: on the one hand, of dividing wholes into parts and partitioning modules into submodules, analyzing complexes into component features, drawing distinctions; on the other hand, of composing modules out of parts and members and subclasses, combining features into complexes, and making connections. Such composition or decomposition is normally effected or assisted or consolidated by the application of labes, names oredicates, etc. Thus, for example, temporally diverse events are brought together under a proper name or identified as making up 'an object' or 'a module'.

Weighting
The second logical step on conceptual design is to give weights for each component. When some relevant objects of a design are missing from another, we might perhaps better think that the two designs contain some classes sorted differently into relevant and irrelevant kinds. Some relevant objects in the one design, rather than being absent from the other, are present as irrelevant kinds; some differences among designs are not so much in entities comprised as in emphasis or accent, and these differences are no less consequential. Emphasis or w weighting is not always binary as is a sorting into relevant and irrelevant kinds or into important or unimportant features. Ratings of relevance, importance, utility, value often yield hierarchies rather than dichotomies. Such weightings are also instances of a particular type of ordering.

Ordering
Designs not differing in entities or emphasis may differ in ordering. Ordering of a different sort pervade perception and practical cognition. The classic waterfall style ordering of software lifecycle model follows the linear logical sequence of development activities, but the spiral or iterative lifecycle model curls the straight logical line of sequential activities into a circle. Orderings alter with

circumstances and objectives. As we often see in various design diagrams, the nature of shapes (icons) changes under different geometries, so do perceived patterns change under different orderings. Radical reordering of another sort occurs in building a unified and comprehensive image of a system from temporally, spatially and quantitatively heterogeneous observation s and other items of information. All measurement is based upon order. Only through suitable arrangements and groupings we can handle vast quantities of material perceptually or cognitively.

Deletion and Supplementation

Also, the making of one design out of another usually involves some extensive weeding out and filling – actual excision of some old and supply of some new material. According to psychology, in everyday life, we find what we are prepared to find, and we are likely to be blind to what neither helps or hinders our pursuits. In the painful experience of proofreading and the more joyful one of watching a skilled magician, we incurably miss something that is there and see something that is not there. Memory edits more ruthlessly. And even within what we do perceive and remember, we dismiss as illusory or negligible what cannot be fitted into the architecture of the design we are building. Perhaps the most spectacular metaphorical case of supplementation can be found in the perception of motion. There is a famous psychological phenomenon: under carefully controlled conditions, if two spots of light are flashed a short distance apart and in quick interval, the viewer normally sees a spot of light moving continuously along a path from the first position to the second. Another experiment showed that if the first stimulus spot is circular and the second square, the seen moving spot transforms smoothly from circle to square. Moreover, if a barrier of light is imposed between the two stimulus pots, the moving spot detours around the barrier. Just why these supplementations occur as they do si a fascinating subject for speculation.

Deformation

Finally some changes are reshaping or deformations that may be considered either corrections or distortions according to the designer's point of view. This process step is important because it is the final touch of design presentation rhetoric.

These are ways of that designs are made. As Goodman wrote above classification is not comprehensive or clearcut or mandatory. Often the actual processses will occur in combination or in random sequence. For example, some changes may be considered alternatively as re-weighting or reshaping or as all of these, and some deletions are all matters of differences in composition.

Design making process always starts from designs already in hand. At first, there is a kind of knowledge base which contains all existing designs already made. Every design activity is just retrieving some information from there and process it somehow and putting back result into the knowledge base again. There are no predetermined sequence of process steps. Anything can occur in any order.

NATURE OF LANGUAGE

Major tool we use in design construction is the language consists of a variety of symbols. We must be careful about the essential nature of this tool. Most important feature of language is the dynamics of change. About this issue, Nakamoto Tominaga, a young philosopher of 18^{th} century Japan, made an important finding.

Tominaga (1715 – 46, died very young) was a son of a rich merchant in Osaka. His father was a member of five sponsors of a merchant academy to study Confucianism named "Kaitoku-Do" (House of Virtue). He studied there but kicked out when he was 15 years old because he wrote an article criticizing all Confucian philosophers in the past. Then he moved to another private school and made an exhaustive critical textual study of the canonical scriptures of Confucianism, Buddhism, and Japanese Shinto.

In 1745, just a year before his early death, he published two books: "Shutsu-Jo-Go-Go"(Emerging after Meditation), and "Okina-no-Fumi" (A Note of an Old Man). The former is a comprehensive criticism of Buddhist sutra, and the latter is a remaking of his first controversial article. A lonely scholar of his time, however, Tominaga did not get much attention from his contemporaries. His unique contribution to the philosophy was discovered after Meiji Revolution. Now, these two books are highly appraised as the big achievement of "Linguistics Turn" movement in Japanese philosophy in Edo-period.

In his trace for the historical process of the formation and transformation of those canons and commentaries, Tominaga found that a basic human desire of "making a difference" and "adding something new" ("kajo" in Japanese) was the underlying cause for the accumulative scriptural writings by scholars of many generations. He also realized the reason that there has been so many different views on various issues were because each one was situated in a particular given position in terms of time, place, and availability of information.

More importantly, he paid great attention to the complexity and ambiguity of languages and ways of expressions, and coined a linguistic guiding principle of "San-Butsu Go-Rui" (3 dimensions and 5 patterns) to help scholars to get the possible true meanings from the texts according to their contexts.

Tominaga's 3 dimensions are:

Personal Preference, Historical Time, and Linguistic Patterns.

Personal Preference

Language cannot be neutral. All discourses reflects author's personal preference or partisanship in debate. Interpretation of words should be along the line of context of the discussion. Language cannot be treated as the carrier of neutral truth.

Historical Time

Language changes over the time. Meaning and use of words will change. Looking back to the short history of software technology, the use of words like "module" or "object" was very naïve in 1960-70s compared to nowadays. Also the meaning of the word "process" radically changes after Belady-Lehman's proposal of software evolution dynamics.

Linguistic Patterns

Tominaga found five patterns of linguistic expression through his textual study of scriptures. They are:

1. Expansion
2. Inclination
3. Afloat
4. Limitation
5. Irony

At a glance these patterns looks like the mode or rhetoric of expression, but Tominaga realized that these patterns are the hidden driving force for the change of language. This is a great finding because, as Witgenstein said, the structure of our language determines the structure of the world.

Looking back my own career in software engineering, structured program design methods in 1960s were somehow influenced by programmers' major concern of program execution process in hardware with limited capability of the age, and tend to be in "limitation" pattern of logic. In the case of my own version of structured design was particular about the form of the logic because of my background as an abstract painter.

Then in 1970s, SASD method came into the scene. They are "expansion" pattern of use of structure from inside of hardware to outside (application system's architecture). Object Oriented method is also considered as one of "expansion" patterns. It is a good example of "Add-on" principle going back to the ontology/epistemology as fundamental basis for design. OO language like Simula or Smalltalk are typical "afloat" pattern. Formal method is considered as "inclination", and agile method is of course an "irony" in design.

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Designing for Design Learning

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ABSTRACT

This paper highlights the need for a science of design to address the needs of technology design learners. For educational technology developers who focus on science of design learning there is an intersection between (1) the curriculum and technology design methodologies they may use to create the learning materials and (2) the design concepts and methodologies they intend to teach in the learning materials. The developers of the NSF-funded Build IT program are experiencing this intersection first-hand as they create and research a technology-supported curriculum that teaches technology design skills and concepts to middle school girls. The Build IT developers would welcome feedback from the CHI community on their design approach and design learning content. The developers can also share with the CHI community what they are learning about the intersection between how they create the materials and the design learning content.

Author Keywords

learner-centered design, user-center design, participatory design

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

The need for a 'science of design' goes beyond technology professionals: it must also reach today's learners. To address the national shortage of information technology professionals, we must attract more youth to the IT field, specifically women and minorities. A focus on design meets two important needs: Attract youth to the field of information technology and provide learning opportunities and entrees into information technology and computer science fields [3]. Furthermore, according to leading national engineering organizations every technologically literate person must have an understanding of the design process. [4,5,6,7].

The questions are: Can we distill a science of design for technology design learners? And if we can, how can educational technology and technology-supported curriculum developers teach design concepts and methodologies well?

It is interesting to note that for educational technology and curriculum developers, there is an intersection between (1) the curriculum and technology design methodologies they may use (e.g. user-centered design, participatory design, learner-centered design) to create the learning materials and (2) the design concepts and methodologies they intend to teach in the learning materials. The developers of the NSF-funded Build IT program are experiencing this intersection first-hand as they create and research a technology-supported curriculum that teaches technology design skills and concepts, as they are defined by engineering and technology fluency policy [5,6,7]. Build IT developers use user-centered design, participatory design, and Understanding by Design (UbD) [8] methodologies to create the curriculum. The developers would welcome feedback from the CHI community on their design approach and design learning content. The developers can share with the CHI community what they are learning about the intersection between how they create the materials and the design learning content.

THE BUILD IT PROGRAM AND DESIGN

Build IT development partners, SRI International (SRI) and Girls Incorporated of Alameda County (Girls Inc.), are collaborating to develop and implement a design-based curriculum that promotes middle school girls' information technology (IT) fluency and incorporates the STEM content of mathematics and computer science.

In Build IT, an after school and two-week summer program, middle school girls explore and tinker with existing information technologies (e.g. web-based tools, collaboration tools, wireless and mobile devices) and create some of their own information technologies using simple programming tools. Throughout Build IT, girls use The Design Process (see Figure 1) and experience user-centered and participatory design methodologies on a variety of information technology development projects [1,2].

The developers of Build IT start with a design methodology, UbD, to develop the technology-supported curriculum. Several of the articulated learning goals—the first step in UbD—are specific design skills and concepts from computer science. For example, girls learn concepts such as 'designs have both form and function' and that 'design is a process.' They also learn specific design skills such as defining the problem, user testing, and how to iterate. Embedding design learning and design methodologies throughout the curriculum is key to achieving the overarching goals for the Build IT program. These programmatic goals are to motivate middle school girls to use technology, achieve technology fluency and increase their interest in IT careers.

In addition to the learning goals for the girls, the program also seeks to enhance the Girls Inc. staff's capacity to provide IT fluency programming. While SRI leads the UbD approach, the Girls Inc. staff is experiencing both user-centered and participatory design approaches in working with SRI to develop the tech-supported curriculum. Early in the development process, the SRI team learned that the staff, even though they were nervous about using many of the technologies, had more to learn about design than the technologies. Creating the curriculum together using all of these methodologies illuminates for the staff the process of design enabling them to incorporate important language, tips and strategies into the curriculum for future implementations at this Girls Inc. site and at Girls Inc.'s 1500 affiliate locations.

Achieving Technology Fluency: What Are Girls Learning about Design?

The summative and formative evaluations of Build IT's first year (Units 1, 2, and 3) [1,2] show that the 76 girls who participated in Build IT are learning design and technology skills but conceptual understanding of design and information technology concepts were not understood by the majority of these girls. In the second year of the project, the development team made changes to the curriculum to make the design learning goals more explicit to the youth leaders and the girls. The curriculum also provides time for the youth to reflect on these concepts; while the professional development for the youth leaders provides time for them to reflect on these concepts at an adult level.

Is Design Attracting Girls to IT Careers?

The Build IT first year evaluations also show that girls' images of IT careers as solitary and boring are changing significantly to collaborative, fun, and intellectually stimulating. This change in perception is in stark contrast to pre-test data and girls' general impressions of IT careers as solitary, boring, and repetitive. The year two evaluations seek to understand the elements of the Build IT program that lead to this change. Design activities and the interactions with IT professionals who share their design methodologies are two elements that researchers are investigating.

CONCLUSION

Build IT uses design to both entice and teach girls information technology and computer science concepts. Within the technology-infused curriculum, there are technology fluency performance tasks that enable the girls to demonstrate what they are learning to their peers, youth leaders, parents, teachers, and the larger community. Design methodologies (UbD, user-center design, participatory design) are also playing a critical role in the development of the curriculum and the capacity building of the Girls Inc. staff to provide the curriculum. This intersection of design—designing a curriculum and technologies to teach design and the content of design learning—needs further research to understand how best to teach design, especially to middle and high school students and their teachers who may have limited experience with design concepts and methodologies.

The CHI community could offer valuable feedback on Build IT team's efforts to distill design concepts and methodologies. For example, the design process, which is much more complicated than Figure 1 depicts, shows the choices that the developers made to teach this complicated process to middle school youth. Likewise, user-centered design and participatory design have many elements that may confuse youth rather than encourage their learning. Here too, developers have made choices that would benefit from feedback from the CHI community.

ACKNOWLEDGMENTS

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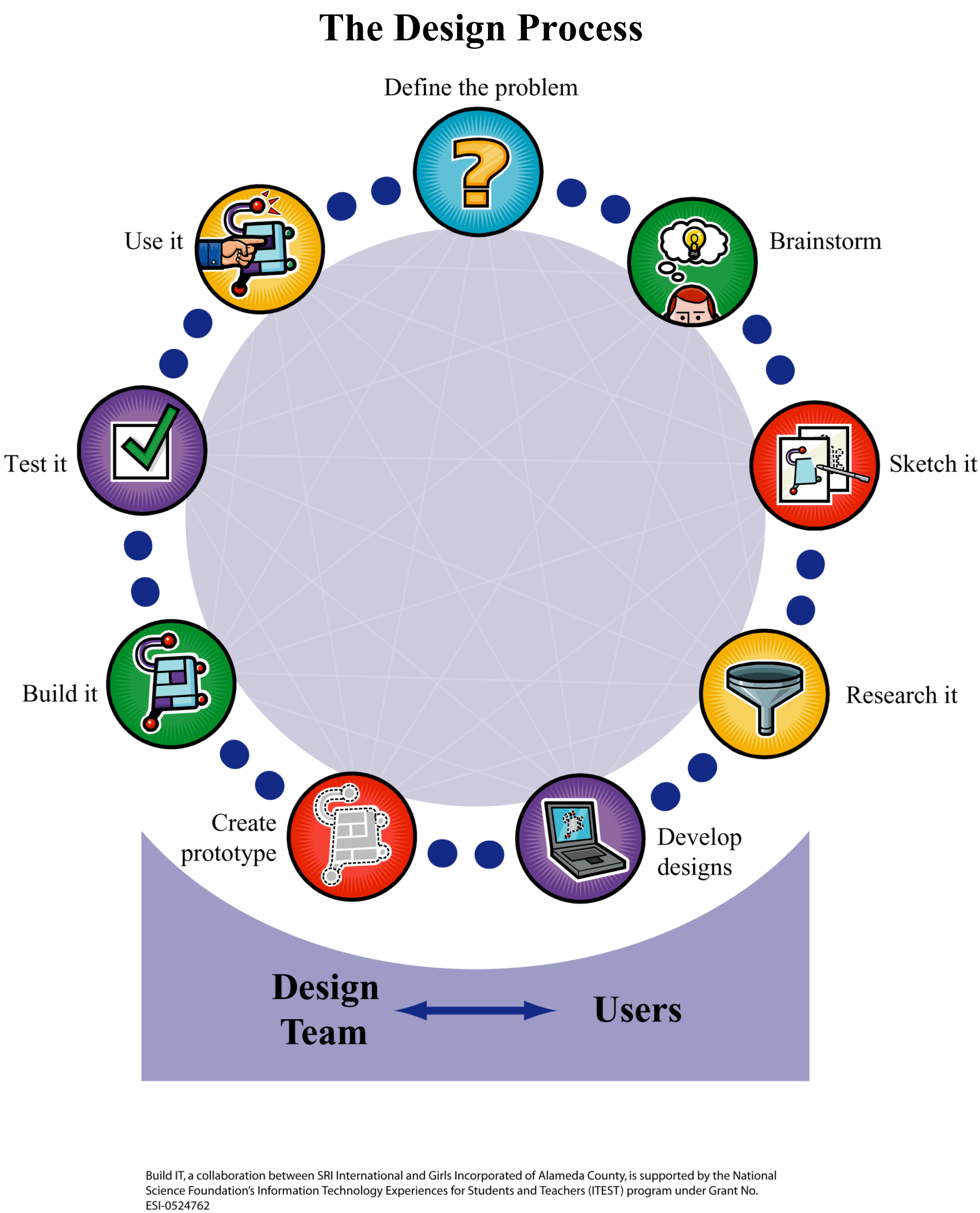

Figure 1. The Design Process poster used in the Build IT curriculum.

Collaborative Design and the Science of Design

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INTRODUCTION

Design has emerged as a fundamental topic for the CHI community. The great importance of design is recognized by research communities in different domains including design history and in studies of computer supported cooperative work (CSCW). Victor Margolin (2002), a noted design historian, entitled his book *The Politics of the Artificial* as both a nod to and a critique of Herbert Simon's call for a science of the artificial (Simon 1969). While embracing Simon's broad and inclusive definition of design, Margolin wishes to move studies of design away from Simon's focus on the creation of objective models of the design process and towards the development of a critical theory of design practice.

While referring to Simon in the title and content of his book *The Politics of the Artificial*, Margolin notes that Simon was not the first or only person to remark upon the need to rethink and broaden conceptions of design. In 1946, Laszlo Moholy-Nagy stated that design "is an attitude which everyone should have; namely the attitude of the planner—whether it is a matter of family relationships or labor relationships or the producing of an object of utilitarian character or of free art work, or whatever it may be. This is planning, organizing, designing (Moholy-Nagy 1946)." In 1992, Buchanan published an article about the messiness of design problems called "Wicked Problems in Design Thinking (Buchanan 1992)" in which he expanded the scope of design practice to include symbolic and visual communications, material objects, organized services, complex systems, and environments for living, working, playing, and learning. According to Margolin (2002): "Central to Buchanan's argument for a widened design practice is his conviction that design is a new liberal art of technological culture that has the capacity to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present (Buchanan 1992; Margolin 2002)."

Margolin (2002) proposes four topics for design studies: design products, design discourse, design metadiscourse, and design practice. The *study of design products* emphasizes the interpretation of products through semiotics and rhetoric, but also through methods drawn from structuralism, poststructuralism, and psychoanalysis. The *study of design discourse* emphasizes arguments about what design is and might be and is the locus for design philosophy, theory and criticism. The *study of the metadiscourse* of design studies is the place for reflection on the entire field and how its different components operate in relation to each other and would include historiography, critical theory, and the sociology of knowledge. The *study of design practice* emphasizes the people, processes, and organizations that are involved in product planning and production as well as those organizations involved with design policies. The study of design practice belongs to the realm of social action that has traditionally been studied by sociologists, anthropologists, psychologists, and other social scientists. Within this latter vein, my research in the field of CSCW uses qualitative social science methods to study of collaborative design practice.

TWO STUDIES OF COLLABORATIVE DESIGN

I undertook two long term ethnographic studies of collaboration at two research sites that differed according to domain, scale, degree of multidisciplinarity, and degree of geographic distributedness.

Collaborative Design of a Museum Exhibition

This research used ethnographic methods to understand how a team of designers used physical artifacts and social practices to collaborate (Lee 2005). I wanted to find out what communities of practice were involved, what sorts of practices they used, and how they used artifacts.

The site for the fieldwork was a project to design a traveling exhibition about wild and domestic dogs. The project was sponsored by a large natural history museum, hereafter referred to as the Natural History Museum. An interdisciplinary team of designers, most of them located on-site, was charged with the responsibility to design the exhibition.

At any given time there was a core group that worked intensively on the project and a peripheral group of participants who made occasional contributions through participation in meetings and provision of information or artifacts. The core design team was comprised of educators/writers, exhibit designers (an industrial designer and graphic artist by training), a builder, and off-site scientific advisors/curators.

I used ethnographic methods such as participant-observation and interviewing and also used documentary analysis. Data was collected at the Natural History Museum for over a year between December 2001 and March 2003. I spent well over two hundred hours in the field with members of the exhibition design team and collected over a thousand pages of field notes, documents, and photographs.

A full description of analysis and findings is available elsewhere (Lee 2005), however the findings can be summarized here. A taxonomy of *boundary negotiating artifacts* was created to provide a unique lens through which to view how artifacts are used in the space that exists between communities of practice and to illustrate that the use of artifacts is often inconsistent with the concept of boundary objects (Bowker and Star 1999; Star and Griesemer 1989). Boundary negotiating artifacts:

- Are surrounded by sets of practices that may or may not be agreed upon by participants
- Facilitate the crossing of boundaries (transmitting information)
- Facilitate the pushing and establishing of boundaries (dividing labor)
- May seem “effortful” in use as opposed to effortless
- Are fluid—often incorporated or transformed into other artifacts
- Can be largely sufficient for collaboration
- Are possible predecessors of boundary objects

The implications of boundary negotiating artifacts for CSCW extend beyond a simple critique of boundary objects, or how the term is used, to a more generalized critique about how we conceptualize collaborative work itself. Strauss (1988) noted that projects could be mapped according to two axes: from routine to non-routine and from simple to complex. On these axes, projects fall along a continuum. Routine projects have project paths that have been traversed frequently, with clear and anticipatable steps, experienced workers, an established division of labor, stable resources, and strategies for managing expected contingencies. Non-routine projects would have projects paths that have been traversed infrequently, with unclear steps, inexperienced workers, an unclear division of labor, etc. Complex work includes that which has many workers and many types of and levels of workers, a complicated division of labor, variable worker’s commitments, possibly more than one explicit project goal, and a complex organization context for the projects. A simple project would have few workers, few types and levels of workers, a simple division of labor, similar levels of commitments from workers, an explicit project goal and a simple organizational context.

We might consider that not only do projects fall along the two dimensions Strauss described, but particular constellations of artifact types may also correspond with project location on those two axes. At each point in space, perhaps a whole taxonomy of artifacts including, but not limited to, boundary negotiating artifacts and boundary objects, may be prevalent.

Collaborative work can involve discovering, making, testing, developing, and arguing over practices and how to instantiate those practices into intermediary artifacts and end products. Collaborative work can be highly contested and practices and artifacts are not always well understood. Alignments can be partial, shared understanding between groups can be spotty, and these breaks in alignment extend to understanding and use of representational and coordinative artifacts.

Collaborative Design of Cyberinfrastructure

Despite their rapid proliferation, there has been little examination of the coordination and social practices of cyberinfrastructure projects. We used the notion of "human infrastructure" to explore how human and organizational arrangements share properties with technological infrastructures. We conducted an 18-month ethnographic study of a large-scale distributed biomedical cyberinfrastructure project and discovered that human infrastructure is shaped by a combination of both new and traditional team and organizational structures. Our data called into question a focus on distributed teams as the means for accomplishing distributed work and we argue for using human infrastructure as an alternative perspective for understanding how distributed collaboration is accomplished in big science (Lee et al. 2006).

The research site was the Function Biomedical Informatics Research Network (FBIRN), a large-scale project in the area of biomedical research funded by the U.S. National Institutes of Health (NIH). The FBIRN is a consortium of scientists from 13 different institutions distributed throughout the U.S. The FBIRN is part of a larger umbrella project, the NIH-sponsored BIRN (Biomedical Informatics Research Network).

The major goal of the FBIRN test bed project is to develop tools to make multi-site functional MRI (Magnetic Resonance Imaging) studies a common research practice. Single-site samples tend to be small due to the difficulty of locating and enrolling appropriate research subjects, limited access to expensive machines, and the labor intensive nature of conducting clinical assessments and in-scanner cognitive tests. Multi-site studies can ameliorate the problem of inadequate sampling in medical research, but variability among machines, software, and methods compromise the value of multi-site imaging datasets. This challenge of pooling data across sites is already daunting, but the responsibility of the FBIRN project, and its umbrella project, is larger still. FBIRN has been created to drive the development of cyberinfrastructure that is truly usable for scientists. The challenges are complex, involving technical, scientific, and organizational elements.

While it will be years before FBIRN will be able to fulfill its long term goal of having a large data repository where researchers can routinely contribute and share research data to create larger or new kinds of samples, much has been accomplished in three years of work. The FBIRN has successfully developed de novo tools for multi-site functional MRI studies, for data collection, management, sharing, and analysis. It has collected several unique datasets that include imaging and assessment data from ten different universities; the tools, methods, and datasets in their initial forms are currently available to the research community.

We engaged with this group for 18 months and undertook participant observation at 36 bi-weekly meetings, remote teleconferencing and videoconferencing meetings of various working groups and all-FBIRN meetings, and half-yearly all-hands meetings and have also read associated email list messages. Twenty in-depth interviews were completed with individuals from ten different institutions.

A full description of analysis and findings is available elsewhere (Lee et al. 2006), however the findings can be summarized here. Others have found that team membership and team borders are often fuzzy in distributed organizations (Mortensen and Hinds 2002). We found something even more surprising: *FBIRN participants often did not know whether or not they themselves were part of a team.* In particular, FBIRN members frequently had no idea if their task forces were still active or if they were even part of a working group.

While the "inner-circle" of the FBIRN, i.e. the senior investigators at each site, and those who participate in many cross-site meetings, is identifiable to most participants, there is no defined outer periphery of membership. For example, on the extreme periphery, hospital research coordinators may collect crucial data for the BIRN yet know little or nothing about FBIRN or the BIRN Project. Although FBIRN participants know that there are people who perform these tasks, they may not know who these people are at their own site and very few know who they are at other sites.

Rather than being a disadvantage, not having a clear view of the FBIRN membership may actually be advantageous for collaboration. In a large-scale cyberinfrastructure project, people develop selective views of the entire network. The complexity of all the different working groups, lab memberships, and disciplines is far too great for any single member to follow. Thus, members develop selective knowledge for those aspects of the human infrastructure that they need to interact with in order to coordinate. This imperfect knowledge of the network may actually be *ecologically beneficial* for interacting in the network. The complete organizational structure is, in many cases, hidden from view for those who participate in it.

What is remarkable is not that those participating in the project have a limited organizational view, rather what is remarkable is that the organization continues to function in the absence of this sort of mutual visibility. *Participants can successfully accomplish work with a partial view of the organizational membership and structure*.

We are accustomed to hearing arguments advanced about the changing nature of work and collaboration. CSCW is quite used to looking at forms of distributed work and virtual organizations that span geographical and institutional boundaries through the use of IT. The idea that technology might be able to create a virtual space for interaction, a site at which people can come together and engage in collective (albeit contested) activities, develop and share new practices, and (in the case of scientific work) generate new scientific knowledge, is by no means unfamiliar, because it fits into a conventional picture of traditional, hierarchical organizations being replaced with dynamic, networked organizational forms. What we find though, is that these ideas fit at best poorly as ways to understand FBIRN.

Traditional organizational structures tell part of the FBIRN story, but fail to account for the whole. Distributed teams tell part of the FBIRN story, but also fail to account for the whole. Clearly, people come together in dynamic, interdisciplinary arrangements that cross organizational boundaries and respond to immediate and changing needs. However, much of the work does not have this flavor; not only are team boundaries unclear, but even one's own membership in those teams is uncertain; the concept of "team" seems to apply poorly when people do not even realize that they are members. Personal networks tell part of the FBIRN story, but similarly fail to account for the whole. FBIRN includes many overlapping networks and is embedded in others. What we find at work is a much more complex and heterogeneous form of organization than any of these accounts provide. By thinking about participation in terms of human infrastructure, we gain a rather different perspective. Infrastructure mediates between the local and global. The human infrastructure of cyberinfrastructure achieves collective action not by making my relationship to the whole visible but by making it invisible, indeed irrelevant. The human infrastructure does not create a distributed team; it dissolves the very need for one.

If the notion of team dissolves here, then what of the virtual space that brings that team together? In the case of the FBIRN, people are not grappling with a disembodied and disembedded global cyberinfrastructure, but rather a series of local concerns and arrangements which blend in and can be achieved through a human and technological infrastructure. The cyberinfrastructure provides a means of producing and transforming local concerns – institutional prestige, academic power relations, organizational relationships, access to appropriate scientific data, access to subjects, and so on.

We have found the metaphor of infrastructure useful here precisely because of the way it allows us to talk about the human structures relationally in just the same way as we might approach technological infrastructures in CSCW terms. We have argued that a view on human infrastructure might equally serve to problematize the teams and networks by which distributed collaboration is frequently, and perhaps all too easily, explained.

DISCUSSION

The collaborative design projects described above were quite different: One was engaged in creating a new museum exhibition, the other was engaged in creating a new cyberinfrastructure; One had a core group of approximately eight people, the other had a core group six times larger; One group required people trained in several distinct disciplines to work together constantly, while the other group tended to bring together people who already had similar disciplinary inclinations; One project group was almost entirely co-located, while the other was distributed across 13 different institutions. Despite the differences between these sites, they were both collaborative design projects and there are some common themes that call for further investigation.

The undertaking of complex collaborative design entails innovation on two levels: joint learning about how to collaborate and coordinate work, and; joint learning in how to represent and instantiate a design that does not yet exist. Participants in the cyberinfrastructure process were able to successfully accomplish work with a partial view of the organizational membership and structure while participants in the museum exhibition design project were able to accomplish work with a partial view of coordinative artifacts and practices. My research suggests that there is not just "one kind" of collaborative design, but that there may be several or perhaps a few different axes along which design projects fall as suggested by Strauss.

The concept of partial alignment or partial view also recurs in these research projects. A great deal of work in CSCW and in related fields, such as Information Science, have usefully focused on notions of standardization and standards for understanding how complex collaborations create information systems, but researchers might also usefully study what happens before or in lieu of standardization and to focus on the improvisation that is necessary to innovate in the collaborative design, not just in information systems, but also in collaborative design in general. More ethnographic studies of collaborative design would help establish a base of theories on which to build, at least in part, a science of design.

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Using Theoretical Ideas to Stimulate Creativity and Participation in Design

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ABSTRACT
A science of design should be about the *process of designing*, including the methods, techniques and tools to support the design process. Understanding the relationship between creativity and the design process is the main goal of this paper. Towards that end I outline a method for interface design that is inspired by creative practices in furniture design. Creativity is defined as the act of finding an inspirational idea outside a design profession, which is then expressible with the materials of the profession. Social creativity *transforms* the idea into realization. Two interactive systems the author has been involved in designing (Janus, FLE Assistant) are analyzed using this approach from a socio-cultural perspective. The retrospective analysis revealed how theoretical ideas (reflection-in-action; generalized other) served as inspiration for the designs as well as provided affordances and constraints for software realization. The sub processes involved in transforming the ideas into user interface designs constitute the first steps of a design method for theory-informed collaborative design.

Author Keywords
Creativity, social creativity, socio-cultural perspectives, extrinsic motivation, appropriation, externalization, theory-informed design, Janus, reflection-in-action, FLE-Assistant, generalized-other

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
There is a huge body of literature on creativity. Most of it centers on the creative acts of individuals. For example, Csikszentmihalyi [1996] interviewed 100 well-known creative people (inventors, artist) to identify what they have in common and how creativity can explain breakthroughs in their thinking and outcomes. Creativity is a combination of accidental discovery, seeing connections, and lots of hard work. The former is not associated with expertise per se, but with a keen sense of awareness of the environment, openness to sudden impulses, and playfulness when it comes to the possibilities of un-appropriated design material. I refer to this as *everyday creativity.* This is the act of ordinary people in their everyday lives in order to bring new insights into their lives and make new connections for their improved understanding. It is also about expressing this insight, discovery and connection in tangible form so that it can be shared with others. Related to this is *social creativity* [Arias et al., 2004; Fischer, Scharff & Ye, 2004], which has been defined as collective performance producing shared understanding and outcome that outperform the sum of what individuals can do and produce on their own or represent in their personal perspectives [Stahl, 2006]. This paper attempts to integrate a semi-professional form of everyday creativity with social creativity in order to develop a method of *theory-informed collaborative design*. It is researched from a socio-cultural perspective [Wertsch, 1991; 1998] to provide a new and unique account of creativity. This is accomplished by studying the impact of creativity on specific designs (concrete design artifacts) and profiling this in terms of "trajectories of participation" [Greeno, 1997] guided by a *conceptual-to-physical* path. Conceptual in this context is meant abstract objects (ideas) shared by a community of users, following the findings of Popper and Bereiter [e.g. Bereiter & Scardamalia, 2003]. For simplicity I use the term physical artifact to mean concrete objects, also implying computational artifacts although they may embody elements that are not strictly physical.

Creativity has received considerable attention in HCI and CSCW over the past 10 years, mostly from within the computer and cognitive sciences. Three seminal contributions are "Bringing design to software" [Winograd, 1996] and two reports from the National Research Council in the United States on information technology and creativity [Mitchell, Inouye & Blumenthal, 2003] and "Creativity Support Tools" [Shneiderman et al., 2005]. The first work identifies how the practice of software design can be improved by applying lessons from other areas of design. The contributors provide examples of design from arts, architecture, product design, early interactive software systems, and participatory design. The second work addresses creativity in terms of the needs of creative people, i.e. professionals making computer games, animated films, computational architecture, and interactive art (to name a few). The last contribution is a compiled report that documents the results of a workshop on "Creativity Support Tools," which more specifically addresses the issues raised in the previous contribution in terms of how creative practices can be supported by a new generation of information technology [Shneiderman et al., 2005].

This paper was stimulated by the above initiatives, but departs from them in significant ways. It takes inspiration from a design profession outside of interactive systems design as advocated by [Winograd, 1996] and it suggests a way to integrate creativity with information technology as proposed by [Mitchell, Inouye & Blumenthal, 2003] and [Shneiderman et al., 2005]. In particular, I address the issues of design methodology by suggesting an approach for transforming abstract objects (ideas) into concrete objects as a form of "externalization" [Vygotsky, 1978]. Creative practices in architecture, furniture design, and the arts as well as the socio-cultural approach to learning and development [Wertsch, 1991; 1998] have been the main inspirations of the approach.

The long-term aim of this work is to provide a *socio-cultural account of creativity*, starting not with brilliant individuals but with brilliant ideas and the creative acts of ordinary people (everyday creativity). Trajectories of participation (social creativity) function as scaffolds (Vygotsky, 19878) to guide the further development and expression of the ideas. The other aim is to provide examples of the phenomena (products and processes). The paper starts by outlining the design process behind an award-winning chair in the Nordic design tradition in order to motivate the need for creativity in the early phases of the design process. Next, it surveys past work in theory-based design in HCI and CSCW (this and rest is abbreviated). A socio-cultural version of theory-informed design is developed and illustrated by discussing the design process behind two interactive systems the author has been involved in designing (Janus, FLE-Assistant). These systems were inspired by the theories of D.A. Schön (refection-in-action) [Schön, 1983] and G.H. Mead (generalized other) [Mead, 1934], respectively.

CREATIVITY AND DESIGN

Designers of user interfaces to computer systems are heavily involved (directly or indirectly) with usability, usefulness, enjoyment (pleasure to use), and domain-specific needs. Creativity, especially in the early phases, has not received the same attention, but there are notable exceptions [e.g. Yamamoto & Nakakoji, 2005]. The questions explored in this paper are 1) how to define a space for creativity in the early phases of user interface design, i.e. before designers start to think in terms of software objects (software components, GUI objects, programs, and systems), and 2) how to trace the development of the inspirational idea into a user interface design as it unfolds over time. The motivation for this has been to look outside of software design to find a comparable domain user interface design can draw on, and adopt useful ideas from it (processes, methods, techniques). Furniture design is one such domain.

Pieces of furniture (chairs, tables, lamps) and interactive systems are artifacts (tools) people use to accomplish everyday tasks or fulfill certain needs and desires. These are supported with affordances and constraints for realizing those needs [Norman, 1988; 1999]. Usability, usefulness, pleasure to use, and domain-specific needs are equally important to furniture designers, as they are to user interface designers – but not exclusively. Furniture designers also have to integrate creativity with utility to succeed. The Norwegian designer Olav Eldøy [Eldøy, 2006] explained the role of creativity as the first step of his design process in the following way: 1) find a recognizable idea that can be expressed in physical form 2) balance creativity against the usage requirement, and 3) provide a construction that affords production and export. All phases were essential for the design of the award winning Peel chair he is known for (Figure 1). When a design fails, according to Eldøy [2006], it is often as a result of not being able to pass through the latter stages (2-3).

Figure 1. Peel chair by Olav Eldøy, produced by Stokke, Norway (2002). Orange peels falling to the ground have inspired this design.

Finding a recognizable idea that can be expressed in physical form has been a key to success for many designers, but it is not a common way to design user interfaces. A reason for this could be that a software product is not a physical artifact in the same way a chair is. Alan Kay has a said that a computer interface is more like a book to read or a car to drive [Kay, 1984], which would imply that the above metaphor cannot be adopted as is. Instead, I turn to an analogous metaphor – *genius loci* (spirit of a place; site; surrounding nature) in architecture [Nordberg-Schultz, 1985]. A working hypothesis in this paper is that theories, models, concepts, and notions, in sum *ideas*, might serve as inspiration for designers of software applications in the same way as genius loci have served as inspiration for designers of the built environment.

Despite the claimed similarities between pieces of furniture and computer applications as tools for everyday use there are also significant differences that should not be overlooked. In many respects computer applications are more complex that furniture. An application has a large number of interacting components (like a complex machinery), multiple levels of representation spanning concrete to abstract systems (hardware, software, user interface data base), and it interacts with users in different organizations (developers, managers, support, super users, end users). Social creativity addresses these issues by bringing together stakeholders representing the different points of view (communities of practice) and fields of expertise (communities of interest) in order to manage the complexity associated with designing and implementing interactive systems in user organizations [Fischer, 2001].

SOCIO-CULTURAL APPROACH

The following concepts are used in the analysis of tracing the transformation of abstract ideas into concrete expressions in two interactive systems: extrinsic motivation, appropriation, and externalization.

Extrinsic motivation [e.g. Davis et al., 1992] is when one is motivated by external factors, as opposed to the internal drivers (e.g. pleasure, fun) of intrinsic motivation. Extrinsic motivation drives one to do things for tangible rewards. In this paper the external factors are theoretical ideas and the tangible rewards are concrete expressions of the ideas, which require appropriation and externalization (see below);

Wertsch [1998, p. 53] defines *appropriation* as "the process of taking something that belongs to others and making it one's own." He also argues that the path to appropriation is not always straight and smooth, but sometimes involves tension between what we appropriate and the use we make of it within a particular context. Someone who can appropriate a cultural tool, such as a theoretical idea, can, according to Wertsch, unravel its mysteries and understand its components in order to integrate it into one's daily practices;

Externalization [Vygotsky, 1978; Kaptelinin, 1996] means to put something outside of its original borders. For Vygotsky this meant to put a human function outside of the human body (e.g. thought to speech). The opposite of externalization is internalization (i.e. a child learning a new word so that it can be repeated), which means to transform inter-subjective mental actions (talk with others) to intra-subjective (mental) representations [Kaptelinin, 1996]. In the work of Vygotsky, externalization is studied in conjunction with internalization, but receives a lesser treatment. In the work outlined here externalization is the more elaborated process and borrows additional meaning from the arts in the way artists transform inspirations (e.g. nature) and models (e.g. human body) into physical expressions on canvas or in sculpture.

RETROSPECTIVE ANALYSIS

I have employed a version of "retrospective analysis." Carroll and Kellogg [1989] used this method to identify the "myriad of claims and their interrelations" embodied in Training Wheels and HyperCard in order to determine how the claims were given coherence by being codified in designed artifacts. Their use of the term "psychological claims" (personal theories, conjectures) is in this work replaced by established (shared) theoretical ideas. This is consistent with the socio-cultural approach to development, which puts more emphasis on cultural tools [Wertsch, 1991] and conceptual artifacts [Bereiter & Scardamalia, 2003] than cognitive artifacts [Norman, 1988; Carroll & Kellogg, 1989]. Furthermore, creativity has an important social dimension [Arias et al., 2000; Fischer, Scharff & Ye] that we want to explore within the cultural context. However, a shortcoming of this approach is that many theoretical ideas suffer from being complex and difficult to grasp by newcomers, thus relegating them to a small community of scholars. This is arguably less a dilemma for general theories of human communication, practical action and collaborative learning. The theories that are of special interest are those associated with the socio-cultural approach (Vygotsky and followers) and theories originating within the American Pragmatist tradition (Pierce, James, Dewey, Mead, Schön, Garfinkel). Furthermore the act of appropriation gives the users flexibility in the interpretation of abstract ideas.

TENTATIVE RESULTS

Two systems are used to illustrate the approach of theory-informed collaborative design along the lines proposed above, namely Janus [Fischer, McCall & Morch, 1989; McCall, Fischer & Morch, 1991] and FLE-Assistant [Chen, Dolonen & Mørch, 2003; Mørch, Jondahl & Dolonen, 2005]. Table 1 provides a summarized account of the findings when the two systems are analyzed in terms of the sub-processes and steps of transformation.

Sub-processes	Janus	FLE-assistant
Selection	Reflection-in-action (D.A. Schön)	Generalized other (G.H. Mead)
Appropriation	Action, reflection, action-present, back-talk	Game, roles, rules, roles-organized-according-to-rules
Translation	Work area, design units, critic messages argumentative hypertext	Participation measure, statistics, aggregated performance conceptual awareness, advice

Table 1. Transformation of theoretical ideas into user interface expressions for two interactive systems

Three steps are used to accomplish this:

1. *Selecting* a theoretical idea from a field of research one wishes to explore and understand, stimulated by extrinsic motivation for accomplishing it [Davis et al, 1992]. The idea(s) should be of general interest so that others also share the interest, ultimately leading to concrete results through a collaborative effort, e.g. originating in human communication, collaboration, learning, everyday creativity, practical action;
2. *Appropriating* the idea [Wertsch, 1991] so that its basic elements stand out in a contemporary design context [Schön & Rein, 1994];
3. *Translating* the elements into a user interface design as an act of externalization [Vygotsky, 1978; Kaptelinin, 1996].

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What Cognitive Science Has to Offer for Research on Appropriation and End-User Development

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ABSTRACT
To know how to design requires that we know how designs are used in practice. This paper investigates how this requirement can be addressed to account for cases in which users may also adapt, customize and modify its functionalities, and invent new uses for existing features, in other words, *appropriate* the system. Of particular interest is the question what cognitive science can contribute to understanding appropriation, this way complementing the existing research that has approached it as a social phenomenon. To this end, the paper identifies ways to study appropriation as a cycle of perception and action, as construction of new mental models, as learning of new material and digital properties, and as a creative process in which a user invents novel uses for technology.

Author Keywords
Appropriation, cognitive science.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): User interfaces – Theory and methods; D.2.2 Design tools and techniques: User interfaces.

INTRODUCTION
Development of design towards a scientific practice requires studies on how its principles are put to use, that is, how different designs are actually used by their users. This is because such studies allow validation of design theories and therefore a comparison between different approaches. An approach that poses special requirements for such validation is the idea of turning users into designers by enabling them to customize, modify and develop their tools. The particularity of this approach is visible in the different propositions of how users can be turned into designers. Two examples of such propositions are Participatory Design (PD) and End-User Development (EUD). PD advocates the idea of activating users into design activities together with designers, so as to give users more voice in the design process and to achieve a more appropriate design [6].

In research on EUD and tailorable systems, the attempt is to develop tools that empower every user on her own to adapt the system to be suitable for her particular user needs. In this case, users can – if they wish – be designers who are able to configure the software without the presence of designers. Different approaches are programming by example [9] and tailoring through customization, integration with scripts, and extensions with new functionalities [10,13,21]. Based on these efforts, Fischer et al. are developing a meta-design framework to bring together different tools to integrate different ways to promote "designing of a design process" [4].

However, adapting software through involvement in design and through e.g. tailoring are not the only ways how users find ways to make computer programs more usable and suitable for the task at hand. They are forms of *adaptation through modification*, but they do not cover the adaptations that take place when tools are used for new purposes without being changed. As an example, it is common that people use their email inboxes to store data and not only to store communication. File attachments are kept in the inbox without saving them to the computer's file system, and are and retrieved from there when needed. This adaptation does not change the email program as such but it nevertheless changes the way how it is used.

Adaptation in this broad is sense is called *appropriation* and it can be defined as follows:

> Appropriation is the way in which technologies are adopted, adapted and incorporated into working practice. This might involve customisation in the traditional sense (that is, the explicit reconfiguration of the technology in order to suit local needs), but it might also simply involve making use of the technology for purposes beyond those for which it was originally designed, or to serve new ends. [2]

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Appropriation is therefore a concept that covers all the adaptation activities that user carry out in use time. It is an important concept both for EUD and the development of science of design, because appropriation is the activity that EUD should foster, and in turn, because EUD is an essential part in the attempt to develop a science of design.

Therefore, this paper investigates how appropriation can be studied and what is the value that the studies could bring to EUD and science of design. To achieve a science of design, it is required that its theories of design are validated in real practice, i.e., in user studies. To do this, we need to know the methods and be aware of the theories in other disciplines that also may study how systems are appropriated (and therefore also tailored and customized).

In particular, this paper investigates the value of research in cognitive science for understanding appropriation.

THE OPPORTUNITY OF COGNITIVE SCIENCE

Appropriation has already been a subject of study in many studies with an interpretive approach. These include sociological research on media technologies at home [19], ethnomethodologically oriented mobile messaging research [8,18] and studies in organizational settings [1,15], to name a few.

Some of these studies have proposed different qualifiers to appropriable technologies, using adjectives like equivocality [7], configurationality [20] and user-configurability [10]. Other studies have identified social factors that facilitate appropriation, related e.g. to manager-worker interaction [15] and roles of certain workers in supporting the appropriation in the whole work community [10].

Research this far has thus reached a qualitative consensus on the importance of e.g. flexibility (to recap the idea expressed in the many adjectives listed). There is also some information about the relationships between appropriation and the social organization and interaction in the workplace.

While more research is definitively needed also on these fronts, there is an even bigger gap in studying the same processes on the level of an individual. For instance, there are no studies on how users *perceive* opportunities for action in technology, how the experiences from using technology structure users' *interpretations* that are the starting point for further interpretations, are there differences in individual appropriation styles as there are differences in cognitive styles [3], and so forth.

By recognizing the missing information, it can be acknowledged that understanding appropriation needs also other than social explanations. Naturally, this does not mean that studying social organization and appropriation should be de-emphasized. A cognitive approach is rather just another way to look at a phenomenon in which individual and social forces are reciprocally closely intertwined.

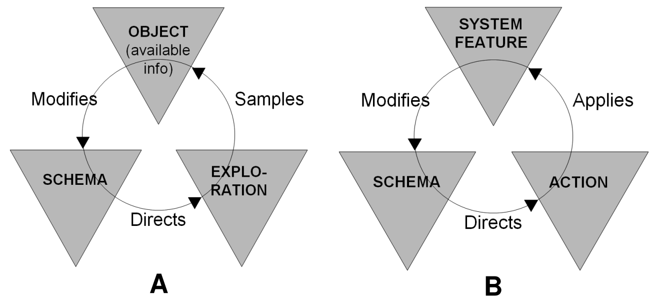

Figure 1. The perceptual cycle by Neisser (A), and an adaptation for the purposes of describing appropriation (B).

TOPICS FOR COGNITIVE APPROPRIATION RESEARCH

This chapter contains a brief review of cognitive phenomena that are worth of systematic research but which so far have not been much addressed. For the programme to build a science of design, understanding these phenomena are important when building understanding of how users will put the features for improved customization into use.

Perception and Action

The cycle of perception and action was already mentioned above, but can be rephrased here. The task is to understand the perceptual process that makes the user aware that a certain technology at hand is suitable for carrying out some action. In turn, when a user puts the perception into action and does something with the technology, she receives feedback from the success of her action, which restructures her interpretation of appropriateness of using the technology in such situations. The perception and action thus form a cycle that is close to Neisser's schema theory (see Figure 1) [14].

Understanding the perceptual process helps to understand how users attend to system features when carrying out their activities.

Mental Models

Since early 1990's, mental models have been influential in the studies how users understand how technology works and how the user interface reflects the inner workings of the system [17,16]. The studies have charted the differences between users' own interpretive models of how the system works and he way how the system actually works. The purpose for which the system is used has been understood as an unambiguous factor. However, the concept of mental models can also be applied to the analysis of users' conceptions of the system's purpose of use.

Learning

Appropriation is a form of learning, because it changes how a user conceptualizes the material and digital properties of a system. Although most of the learning research has been related to educational settings and younger population, there are approaches for studying non-instructed learning among adults: informal and incidental learning [11], transformative learning [12] and self-directed learning [5].

Appropriation as an active constructive process can share similarities with other phenomena of learning. What the science of design can learn from this is how customizing and tailoring change the user's interpretation of the software she is working with.

Creativity and Insight

Psychological research of creativity, creative processes and insight can tell us what factors contribute to inventing the new uses for the system, e.g. by tailoring the system's functionalities for new tasks. Some designs provide more opportunities for such creative adaptations than others, and it would be useful to know what designable factors contribute to it.

DISCUSSION

This paper has charted some of the promising fields of research that cognitive science can contribute to the study of appropriation, which in turn increases understanding of customization and tailoring practices of users. As has been noticed, there are not many existing studies in cognitive science that would be directly applicable for appropriation, but there are many opportunities for such a research. Therefore, this research would not only help in advancing tailoring and EUD research but also cognitive science itself. For tailoring and EUD research, the main contribution would be the complementation of existing socially-oriented findings with cognitive and individual factors. This would provide a more holistic picture of appropriation as a phenomenon, because both individual and social factors are playing a role in the process.

There is also a distinctive role for this research within EUD. Developing technological solutions for users to re-design their tools on their own demands complementary studies on how users actually carry out this design – what are the ways and situations in which the tools are modified, and under what constraints. Understanding use is therefore an important counterpart to understanding how to "design the design-in-use". Appropriation is an important concept in understanding the kind of use that is of interest to EUD research, because it addresses the adaptations holistically: both as modifications that user makes to the software and changes in the software's use that do not require modifications to its structure. This paper has proposed new lines of research to advance studies of this important phenomenon.

PERSONAL RESEARCH BACKGROUND

I am a human-computer interaction (HCI) researcher at the Helsinki Institute for Information Technology and a PhD student of cognitive science at the University of Helsinki. Appropriation is the topic of my doctoral studies, and to learn more about it, I have organized field studies on mobile group communication prototypes in real-life settings, mixing different observation, interviewing and data analysis methods to understand how communication patterns emerge when users engage in social interaction by using the prototypes. My approach on understanding appropriation is multifaceted, and I feel equally attracted to approach it from social sciences and cognitive science points of view.

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From the Inside Out: Design Methodologies of the Self

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ABSTRACT
This workshop position paper proposes an approach to design that is based in models of lived experience found in the domain of performance practice (as exemplified in dance, theatre and somatics). It is grounded on the premise that performance, as a practice-based domain, contains a longstanding history of constructing, iterating and validating experience models. In my research, I apply performance methodologies to the design of technologically mediated experiences and spaces centred in ambient and wearable technologies: technologies that live close to the body. My own research relies on a level of artistic inquiry where presence, meaning, aesthetics, analogy and metaphor, and ethical and social reflection are included as critical modes of creative process.

First person methodologies as defined within performance practice utilize a set of proven, rigorous and repeatable technical strategies. We can term these 'design methodologies of the self', methodologies that utilize the direction of attention in order to access or construct knowledge through the body. In recent years, HCI has adopted a range of experiential approaches to design that include embodied interaction, participatory design and the notion of first-person methodologies to name a few. Even so, the domains of HCI and Performance utilize *differing* frameworks with regard to constructing experience. It is of little surprise that underpinning these differing frameworks are differing sets of assumptions, philosophical histories and value-systems. A comparison and bridging of these varying frameworks reveals a rich, albeit under-theorized area of research and practice. A continued exploration of this common ground between performance and HCI has the potential to expand the rigour, knowledge and quality of research for design methodologies of embodiment, and ultimately the quality of human experience and of the technological systems that contain that experience.

Author Keywords
Performance, somatics, first-person methodologies, attention, movement analysis, Laban effort-shape, wearable technologies, art/design installation, play, social interaction, user experience, ambient environments, choreography of interaction, bodystorming.

ACM Classification Keywords
H5.2. User interfaces *User-Centered Design; Interaction Styles; Theory and Methods*

INTRODUCTION
There is a common ground that exists between the domains of HCI and performance practice: the need to model human experience. It is precisely the differing frames of reference between these domains that can reveal an under-theorized area of practice. The need to have models of interaction that are used to design the experience of the 'user' 'performer' 'enactor' is a shared starting point that is framed through differing methodological strategies. How is interaction conceived, constructed, integrated and tested within a design process? What are the underlying assumptions that differ between these domains?

Examples abound within both performance and HCI that illustrate frameworks of modeling user experience; I focus particularly on those that are based on the position of first-person methodologies, techniques and protocols that articulate models of experience that are constructed "from the inside out". I illustrate my own utilization of these models with 3 case studies that have resulted in prototype systems focused in wearable and ambient technologies.

Performance domains account for experience as a practice based function, one that accesses and constructs knowledge through the physical body. Within my own research I focus on the performance domains of dance, theatre and somatics. In the following pages I review some common views to modeling experience within HCI and Performance, and site examples within each field. I focus particularly on movement and gesture as an expressive indicator of experience.

MODELS FOR EMBODIED EXPERIENCE
Within the field of HCI, Dourish (2001) has argued for a foundation in HCI that validates the notion of an embodied interaction. The need to augment abstract reasoning and

objective meaning with practical action and everyday experience is central to this approach. Suchman's (1987) ethnographic research views activity as situated and embodied, and her interest in purposeful, intentional activity, alongside Nardi's (2001) work in constructing a "theory of practice" within HCI based on the development of activity theory and intimacy between human and machine provide strong bridging links to our work.

GESTURE AS AN ARTIFACT OF INTERACTION

Dance, Theatre and Somatics share a focus on understanding human movement as a means to construct experience. HCI has also begun to explore the use of movement within interaction frameworks. Although movement can be used as an expressive medium simply for its own sake, we can also understand our movement by its direct links to its interaction with artifacts. In Activity Theory, Nardi (2001) illustrates the notion of a "function organ" – a transforming bond with an artifact. A photograph depicts a child listening intently to the radio, the expression of intense concentration suggests the creation of a relation between body and object. In dance and theatre the gesture itself can also become a "function organ", an artifact that creates or enacts a transforming bond between the participant and their own movement. In some of my own explorations of design artifacts, I think of the gesture *itself* as a function organ: the gesture can become the artifact that creates affordances for interaction, that creates meaning for the exchange of data, and for the act of communication that occurs through the experience of this data exchange.

The design of specific gestures that can become enactors is a notion common to theatre and dance practice. Richard Schechner (1985) uses the term *Restoration of Behavior,* to describe gesture as "material". Restored Behavior is organized as sequences of events, scripted actions, or scored movements. He refers to these as strips of behavior, and states that a restored behavior, although "originating from a process, used in the process of rehearsal to make a new process, or performance, the strips of behavior are not themselves process but things, items, *material*". This concept of gesture as source 'material' for designing interaction models is central to our work explicated in this paper.

Augusto Boal (1992) in *Games for Actors and Non-Actors,* states that "bodily movement *is* a thought, and a thought expresses itself in corporeal form". Boal's *arsenal of theatre* can be used to re-enact, or re-materialize the body state that accesses or indexes that thought, or "thought-unity". Grotowski refers to an acting score as a script for designing *point of contact* or connection (Schechner and Hoffman, 1997). In Interaction Design this is the equivalent of interaction schemas, which are navigated in order to construct the instantiation of the interactive experience. Grotowski speaks to the necessity of scripting gestural sequences in order to construct connection schema: "what is an acting score? The acting score is the elements of contact. To take and give the reactions and impulses of contact. If you fix these, then you will have fixed all the context of your associations. Without a fixed score a work of mature art cannot exist" (Schechner and Hoffman, 1997). If we extrapolate from Nardi's example to suggest that gesture can become a "function organ", a mechanism that can assist in defining properties for a scripted interaction score. These gestural function organs have the goal of paralleling processes to move from Grotowski's concept of mature art: works to works of "mature interaction".

FROM EXPERIENCE TO EXPERIENCE MODELING

What do we mean by experience modeling? By bridging domains of performance practice with HCI, we are focusing on an area of enacted cognition: the *enactment* of descriptors, or schemas for movement.

Previous research in the use of exploring experience/ performance methods within the HCI community has occurred in the domain of user-centered and participatory design (Forlizzi and Ford 2000). This has included: *experience prototyping* that fosters an "empathetic" and "embodiment" approach to user-centered and scenario-based design (Buchenau and Suri, 2001; Burns, Dishman, Verplank, and Lassiter, 1994) Interval Research's exploration of *informance*: informative performance and *bodystorming*: physically situated brainstorming, *repping:* re-enacting everyday people's performances, and explorations of how Low-tech solutions can create a design environment that focuses on the design question rather than the tools and techniques (Burns, Dishman, Verplank, and Lassiter, 1994; Scaife, Rogers, Aldrich, and Davies, 1997). Salvador and Howells (1998) shifted the focus group methods to something they called Focus Troupe: a method of using drama to create common context for new product concept end-user evaluations. Simsarian (2003) has explored the use of role-play in extending the richness of the design process. In the *Faraway* project, Andersen, Jacobs, and Polazzi (2003) explored story telling and 'suspension of disbelief' within a context of game and play in a design context. In addition, exploring other subjective aspects of creative process, such as the use of creating ambiguity in design has been described by Gaver (Gaver, Beaver, and Benford 2003) in Ambiguity as a Resource for Design.

In the performance domain, Dance Analysis and Somatics specifically construct systematic articulated movement models directly from the *experience* of the moving body.

Somatics is defined as the *experience from within the lived body* and includes practices such as Feldenkrais and Alexander technique. From the Somatics perspective, knowledge is constructed *through* experience, (Hanna 1998; Johnson 1995) and requires that experience be directed or focused through *awareness*. Experience alone is not a pre-cursor to knowledge acquisition, since experience alone could result merely in conditioning, or in accessing conditioned responses. In Somatics this would be termed "somatic amnesia". However, when experience is specifically directed through the focus of attention, knowledge acquisition takes place which can be referred to as "Somatic learning", an activity expanding the range of what Hanna (1988) terms volitional attention. While Csikszentmihaly (1990) suggests that human experience operates within a limited field of attention, other movement systems within Somatics consider attention to be a generative attribute of awareness that can be augmented, increased through a process of somatic learning (Hanna 1998). Rudolf Laban's movement analysis systems (Laban 1974; Newlove 1993), and the work of other researchers such as Bartenieff (1980) and Blom & Chaplin (1982), are examples of gestural typologies based in experiential practices of dance (Schiphorst 1997; Schiphorst, Calvert, Lee, Welman, Gaudet, 1990), that model a range of qualities and modes of movement. These typologies can be used for gestural mapping and modeling qualitative movement characteristics such as intentionality, interest, attention and body state. They present potential experience models for the classification of aspects of movement, and define a means to approach gestural and choreographic protocols. Participatory design, experience design, performance, theater, dance and somatics share a common focus in modeling or representing human experience.

CASE STUDIES: PROTOTYPING METHODOLOGIES

I present examples from three case studies: systems that have explored the methodological concepts discussed in this paper. They are: 1) whisper[s], the first iteration of a wearable public art installation that used a series of workshops to define the interaction model for connecting and sharing body data; 2) exhale, a wearable public art installation where networked breath is shared between participants in a public space; and 3) soft(n), an interaction prototype developed in conjunction with V2_lab in Rotterdam. *Soft(n)* proposes a scenario for social interaction and the notion of *social intimacy.* Interaction with sensory–enhanced, soft, pliable, tactile, throw-able soft objects afford new approaches to pleasure, movement and play.

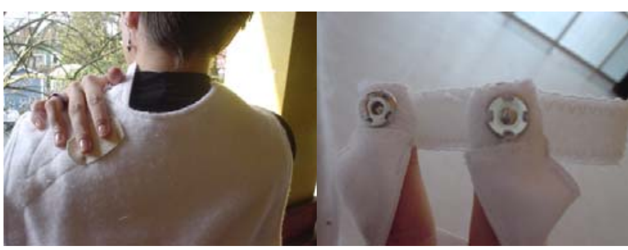
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Figure 10. whisper Garment Design | Snaps | Connection

Case Study 1: whisper[s]

whisper is a real-time interactive public art piece, based on small wearable physiological sensors, micro-controllers, and wireless network transmission, embedded in evocative and playful garments worn by the participants. *whisper* is an acronym for [**w**earable, **h**andheld, **i**ntimate, **s**ensory, **p**hysiological, **e**xpressive, **r**esponse **s**ystem]. Focusing on body state represented through participants' combined heartrate and breath, whisper aims to monitor physical data patterns of the body, mapping heart and breath physiological data onto linked and networked devices worn within a specially designed garment. One of the major themes of the installation *whisper* is the notion of 'paying attention' to one's self, and using this sense of self to connect to, and exchange with another. How can a system create a willingness, a trust, the 'suspension of disbelief' needed to enter into an exchange of information that is otherwise private and 'unknown'? To explore these questions of access to experience we turned to performance methodologies. For example, techniques for extending our bodily awareness through attention to breath and movement are common to performance methodologies found in theatre and dance. Techniques in these domains build both intra-body and inter-body knowledge by focusing on our *perception* of our own physical data. This includes having access to, and agency over our own body state.

Case Study 2: exhale

exhale, continued some of the themes of whisper, refining movement interaction and exploring the sensory landscape of networked breath, and the aural and internal sensation that could be shared. *Exhale* incorporates physical actuators into the wearable garments, creating a more visceral and physical response directly on the body. In *exhale* networked group breath is used as an interface for interaction. This occurs through responses in the linings of skirts worn by the participants. Networked breath is used to create output patterns through a pattern of vibrators and speakers that are embedded in the lining of these sensually evocative skirts.

This response enables a hidden and "inner" one-to-one communication between bodies in the installation, so that one body's breathing can directly affect another body's skirt. At the same time, collective group-breath is made visible on the *exterior* layers of fabric on the skirts by using a specialized fabric printing technique that enables certain fibers to "light up" in a continuous cycle according to collective breath rhythm. Breath bands wrapped around the chest measure the ebb and flow of the breath cycle. As clothing and even costume, the skirts of *exhale* cross our gendered modes of 'wear-ability', and are able to 'contain' both inner and outer senses of self. *exhale* interaction enables an expression of collective group empathy through the use of breath. This artwork integrates somatics and gestural interaction with textiles and garment design, developing new communication metaphors for wearable technologies and wireless networks.

Case Study 3: soft(n) creating emerging behaviour through an ecology of networked soft objects

Soft(n) is an interaction prototype developed in conjunction with V2_lab in Rotterdam. *Soft(n)* proposes a scenario for social interaction and the notion of *social intimacy*. Interaction with sensory–enhanced, soft, pliable, tactile, throw-able soft objects afford new approaches to pleasure, movement and play. A *somatics* approach to *touch* and *kinaesthesia* provides an underlying design framework. The technology developed for *soft(n)* uses the surface of the cushion as an intelligent tactile interface. Making use of a movement analysis system called Laban Effort-Shape, we have developed a model that provides a high-level interpretation of varying qualities of touch and motion trajectory. We have applied the notion of *social intimacy*, through models using through techniques in somatics and performance practice.

CONCLUSION

Our work in designing and testing experience models has illustrated that we can augment experience design with first person performance methodologies found in Theatre, Dance and Somatics.. The experiences within these prototypes illustrate that participants can learn to shift their own threshold of attention, awareness and body-state through the interaction affordances created within the gestures and embedded within the garments and object. They participate in "becoming expert" users of their own physiological data, and in playfully engaging with an emerging co-operative and physically and emotionally negotiated body state and collective system state. Social navigation is created through the participants' perceived internal body data flow [through the fingers, or connection snaps] and represented through the actual data flow [through the server]. As such the installation is also its own experience workshop, and is a starting point to continue to explore methodologies of experience modelling.

ACKNOWLEDGMENTS

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Combining research strategies in interaction design of communication systems for the home

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ABSTRACT
The goal of my research is to design *multi-scale video-mediated communication systems* for the home, that provide synchronous and asynchronous communication between households and also support a smooth transition from peripheral awareness to focused communication. This position paper describes our research strategy and presents the prototypes we have designed.

Categories and Subject Descriptors
H.4.3 [Communications Applications]: Computer conferencing, teleconferencing, and videoconferencing.

General Terms
Design, Human Factors.

Keywords
Video-mediated communication, variable degree of engagement, home communication.

INTRODUCTION
The past few years have seen an explosion of communication and digital imaging technologies in the home, yet video-mediated communication systems remain rare. One problem is that most such systems were designed for work settings, and only support short, synchronous and highly-engaged face-to-face interaction, Mediaspaces [1] provide an alternative, emphasizing the value of long-term video links and allow informal interaction and casual awareness among participants.

In our research, we design *multi-scale video-mediated communication systems* for the home. These systems support a wide range of video communications, from casual asynchronous awareness to synchronous face-to-face interactions. This research requires a deeper understanding of communication practices in the home and careful consideration of privacy issues. In particular, earlier fieldwork [4] has shown that users want to control their degree of engagement with each other, even when communicating with close family and friends. They want to negotiate how they appear to others and reserve the option of withdrawing at any time.

We introduce the concept of *multi-scale communication* [6], which allows a variable degree of engagement among participants and fluid transitions between each level. Some nonvideo-based applications already have this feature. For example, instant messaging makes it easy for users to indicate their current "status" and to adapt the remote conversation to their local context. IM also supports transparent transitions between synchronous and asynchronous communication. Existing video systems, such as video phones and video conferencing systems, lack this ability to move seamlessly from loosely-coupled to highly-coupled interaction.

METHODOLOGY
Our research methodology involves triangulation [5] among "different research strategies, each of which forces a trade-off among different threats to validity", to avoid fundamental problems of complex communication situations. These strategies include observation in the field, technology probes [4], and participatory design workshops [5] to influence the design of prototypes that we develop and capture the context of users. We are also exploring a theory of multi-scale communication systems, which frame a generalizable characterization of video-mediated communication. And we will test this theory with longitudinal field studies.

The technology probes [4] approach allows simultaneously to test the technology in situ, introduce a new prototype which can influence the behavior of users, collect ethnographic and use data and inspire users by provoking the reflection on their everyday life and communication. Similar to technology probes, our prototypes are ambiguous, flexible, open-ended and designed for unanticipated changes, instead of being built for a determinated task. Our focus is on how the user will adopt our systems, will transform them and create personal communications codes. In contrast with evaluation of collaboration in work settings which focuses on task completion, researchers from project centered on the home settings insist on the importance of playfulness [5] and aesthetics [8]. Measuring these subjective criteria is one of the main difficulties in evaluating our communication systems prototypes at home.

We are working on a research project, funded by a major telephone company, and held the first of a series of participatory design workshops on domestic communication. This helped us to identify a variety of user's problems and needs, and confirmed the importance for them of coordination [7] between and within households and emotional involvement in communication at home. This workshop helped me also to understand and design our prototypes for the values of the domestic communication systems users. We have analyzed the ideas proposed by users in a more quantitative way, which allowed us to identify the nature of the information suited to loosely coupled communication situations. Users proposed systems that automatically convey activity, context and location information, but reserved the possibility of explicitly controlling this information.

Pêle-Mêle

My first prototype, Pêle-Mêle [3] is a multiparty video communication system. It supports informal communication by providing awareness of others activity and by helping users to share images of their everyday life, and allows in the same time to communicate through a focused way. As a multi-scale communication, PêleMêle supports a variable degree of engagement among participants. It is designed for closeknit groups of families and friends, to use at home.

The system works in two main phases: it first automatically detects "interesting" situations and allows users to adjust the ''interest'' themselves. It then uses spatial and temporal composition techniques to display at appropriate level of detail. Pêle-Mêle consists of a screen with a video camera connected to a small hidden computer. The screen first displays an overview of all the places it is connected to and then presents a more detailed view of the places where someone is currently communicating. Each representation of a place may combines both live and recorded images that show previous activity. The layout of all the images is shared among Pêle-Mêle instances on a strict WYSIWIS (what-you-see-is-what-you-get) basis [3].

Pêle-Mêle analyses what local users are doing using basic detection techniques and classifies each activity as: *away*, *available* and *engaged*. The activity level observed at each place determines the nature of the video images that represent it: for *away* level, the place is represented by filtered images that illustrate its past; for *available* level, the place is represented by video clips that show its past and a filtered live stream that illustrates its present; for *engaged* level, the place is represented by video clips and a live stream that simultaneously show both its past and present.

Spatial and temporal filters are used, for example, to degrade or delay images to mitigate privacy concerns, or to compose them over time to increase the understanding of each other's activities. Combined with the screen layout, filters help users to perceive the differences between activity levels. Live images from people engaged in a communication are overlaid in the middle of the screen, while images of other available people are shown on the periphery of the display. Smooth animated transitions between these representations ease perception and understanding the state changes. Time is represented by the z axis. Thus, recorded video clips slowly shrink and drift toward the center of the screen to represent the passage of time.

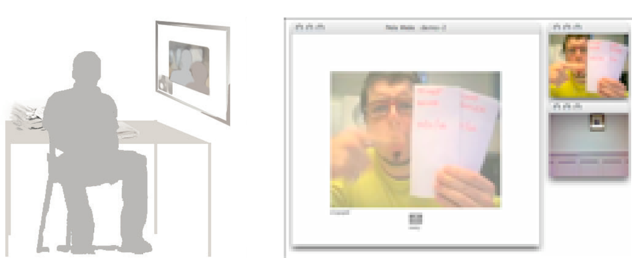

Figure 1. PêleMêle prototype sketch and screen capture.

Informal testing indicates that users quickly perceive the three levels of engagement currently supported by the system. The layout, the auditory feedback and the animations help them perceive the transitions, and they quickly understand how these transitions can be triggered by simple movements. The effectiveness of the spatial and temporal filters in mitigating privacy concerns and supporting better awareness over time is more difficult to assess. Long term use and participatory (re)design workshops will help us get user feedback on these important issues and improve the system in the future to better meet the domestic users needs.

ACTUAL WORK

PêleMêle prototype supports informal communication through three different ways. The first is synchronous way, which implicate focused interactions between users. The second is asynchronous communication, which is perceived as an ambient way of being aware of and present with others. The third way is building a common context of shared pictures, like pictures of users life recorded by the system or messages explicitly left by the users themselves.

Inspired by the workshop participant ideas and by our first prototyping experience, we have designed three other prototypes, one for each of these three aspects of informal communication: Mirror Table, Past-Summarizing Machine and Picture Sharer.

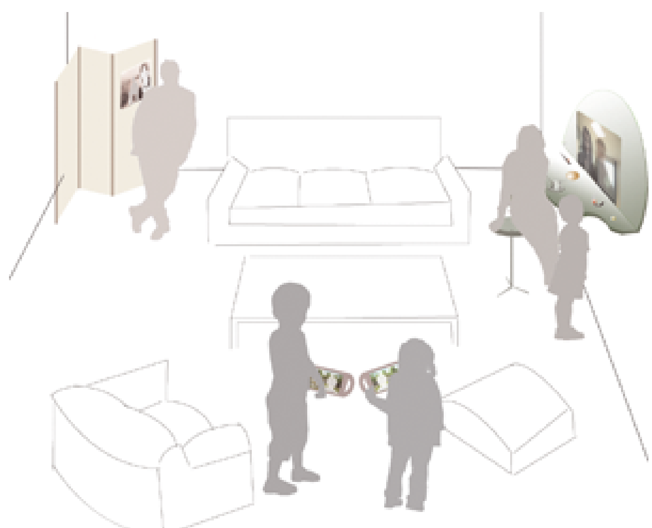

Figure 2. The three prototypes placed in a home setting.

These three image-based communication prototypes are multi-scale systems that support variable levels of engagement and awareness. They are designed to encourage the user to explore and adapt the communication to his needs. With these prototypes, we aim to identify interaction patterns, and to validate and precise multi-scale communication theoretical concepts.

MirrorTable

MirrorTable is a multiparty video communication system designed to encourage spontaneous communication. It uses a dressing table mirror that is actually a screen, with sensors, sliders and leds integrated into the table and a chair equipped with sensors.

When the user sits on the chair or touches an object on the desk, the led lights up. In addition, a video connection is established by chance between available sites. Users can control the detail level of the transmitted video stream, using sliders. When the detail level is high, users can superimpose their faces and obtain an audio connection to enrich the image-based communication.

In the MirrorTable prototype, we are interested in studying patterns of the explicit use of detail reduction in synchronous video communication. We are also interested in comparing chance connections with user-controlled connections.

Past-Summarizing Machine

The Past-Summarizing Machine displays images and videos of previous activities that occurred in the past, to maintain awareness of others. Couples or closeknit family members may stay in touch with each other by exchanging pictures that capture daily activities or important events.

This prototype uses a screen equipped with a video camera connected to a small computer. It records everything in front of the camera and analyses activity in the video stream. When a person approach to the screen, the system plays all recorded clips and displays pictures from each site, at a variable speed depending on the recorded activity level. When there is a great deal of activity, full videos are played at normal frame rates. When activity levels are low, photos taken from time to time are shown instead. Users can move smoothly these two extremes, permitting a continuous scale of temporal details.

The Past-Summarizig Machine prototype, will help us to study users exploration of their and others previous recorded activities.

Picture Sharer

Picture Sharer is designed to display digital photos and video clips and to talk about them with a distant person. This prototype includes a small mobile tablet computer equipped with pressure sensitive handles that glow, and a reversible camera at the top. Picture Sharer can be used like a camera but it is more adapted to show rather than to take images.

At one site, a user touches the prototype's handles, which makes the handles at the other sites glow. The user can then visualize photos and videos that are shared among all sites. If another user takes another Picture Sharer, a video communication link is established. Each user can see his and the other's live video streams superimposed. The user can control the transparency of the picture through pressure on the handles. As in MirrorTable prototype, an audio connection can enrich the video based communication. Picture Sharer uses image-based communication and the visual perception of hand pressure to communicate emotional reactions.

For this last prototype, we want to determinate the importance of emotions and the role of sharing a common context of photos in helping users to keep in touch with each other's.

CONCLUSION

We have completed the implementation of the Pêle-Mêle system and in the early stages of evaluating it. We have also begun development on the *Mirror Table*, *Past-Summarizing Machine* and *Picture Sharer* prototypes.

I would like to participate to this workshop to present and discuss my research and design methodology, which combines multi-scale theory and field methods. My position is that each design and evaluation methodology has advantages and weaknesses. For my research, I need to balance the tradeoff between a generalizable theoretical characterization of video-mediated communication and a specific understanding of domestic practices and routines. I am particularly interested in discussing which design methods are appropriate for evaluating image-based communication systems in the home settings. I am interested also by discussing which evaluation methods are appropriate for defining, with the user, levels of detail a multi-scale communication system should use.

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The Utility of Simple Prototype Tasks in Understanding and Augmenting Real-World Design Behavior

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ABSTRACT
In this paper I argue that progress in describing, understanding and supporting complex, real-world design may be aided by the adoption of a small set of constrained benchmark tasks that capture the essence of generic, unsolved prototypical problem types that recur in real design problems in a variety of domains. There is, of course, a danger that the study of such problems may become divorced from the real world contexts that they are meant to inform. To avoid this, I suggest some methods to insure an ongoing dialectic between efforts to improve performance in these prototype tasks and the study of and participation in fully contextualized real-world design activities.

Author Keywords
Design, design studies, problem solving

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Design is a quintessentially human activity. In the space of problem solving activities, it is not only one of the most difficult, it is also one of the most ill-defined in that the initial conditions, the allowable transformations and the desired end-stand are all typically ill-defined. To further complicate matters, real world design today often involves very large teams consisting of participants from many different academic and cultural backgrounds. Design activities may span many weeks, months or even years. The "goodness" of a design in terms of real impact may not even be known when the design is finished or even implemented and situated in the real world setting. For example, a bridge may function quite adequately for years and then twist apart in a storm. Only then is a weakness in the original design made manifest.

Given the complex nature of design and its contextually embedded nature, it may seem absurd to suggest that any value can be gained through the study of small, controlled prototypical problems as being suggested here. Yet, the history of science shows that the study of simplified models *can* be useful provided several pitfalls are avoided. In this paper, I first define what I mean by a prototypical design task, give some examples and then argue how the study of such tasks may inform "real design." I then outline some ways to ensure that the study of such tasks stays relevant to real-world design.

PROTOTYPICAL DESIGN TASKS
What I mean by a "prototypical design task" is a task which embodies one or more of the most salient, characteristic, and difficult aspects of real design tasks and yet is stripped away from any kind of complex political and cultural context such as commonly occurs in real design. Further, rather than representing a tangled weave of inter-related issues, such tasks are focused on a single difficulty that repeatedly occurs (though in different guises) in real design tasks. Excellent performance on real design tasks often takes specialized knowledge built up over years of study and experience. Such knowledge is often largely tacit and difficult to extract. It is nearly impossible to "control" in any experimental sense. Prototypical tasks do not require this kind of extensive real world knowledge. They can be explained so that most adults in our culture can understand the problem and have the background knowledge to solve it. Furthermore, prototypical tasks have the advantage of being *cheap.* It might be nice to study the relative effectiveness of three or four proposed design methodologies by having comparable groups work on them. However, a real world design project is an expensive undertaking. Even if we could persuade an organization to pay for four different groups to use four different design methods, what would we learn from the outcome? How could we know whether any differences found were due to chance, due to differences in the skills of the participants in the groups, an interaction between the skills and the particular methods or really reflective of an actual effect of

the method itself? Quite clearly, we could not. Only be studying a fair number of groups in each condition could we be reasonably assured of our inferences.

SOME EXAMPLES OF PROTOTYPICAL TASKS

In order to explain what is meant by a prototypical task, a few examples should help. First, consider one of the chief difficulties in real design problems; viz., coming to terms with a host of requirements that seem initially to be somewhat contradictory. Often, finding a design that meets a subset of the requirements is fairly easy while finding a design that meets *all* of the requirements at first seems impossible. The following is offered as a prototype tasks that captures most of the aspects of this real phenomenon but in highly simplified form.

"I am thinking of a real world three-dimensional shape. I can turn this shape so that its projection (or shadow) is a square. In another orientation, the projection is a circle. In still another orientation, the projection is an equilateral triangle. What is the shape?"

I would argue that this problem does not require the solver to know a huge amount about a particular domain such as architecture, computer science or electrical engineering. There is an answer to this problem and yet it is not obvious. If we have some technique, or tool, or method that we think may help people deal with the integration of multiple constraints, we can test such a technique, tool or method on this prototypical problem. In doing so, we can test "ordinary people" in large enough numbers and over a short enough period of time to have a reasonable confidence in a found result. Needless to say, there may be useful tools for dealing with thousands of requirements whose benefits may not be obvious with this prototypical problem. And, conversely, once we find something useful for this prototypical problem, we will want to examine its utility in more ecologically valid situations.

Here is another example. "There are two locked boxes, each containing the other's one and only unique key. The only way to open both boxes is by use of these keys. And, yet I am able to open both boxes. How is this possible?"

In this case, the process that the prototypical example ties into is the blockage caused by an unstated assumption. In real world situations, possible solutions are often precluded by just such unstated assumptions. The thesis is that if we can find a reliable way to make people aware of and to challenge their unstated assumptions in this prototypical problem, we have a reasonable chance that this same way will work at least sometimes in more complex, real-world situations.

SOME BENEFITS AND DANGERS

Some benefits of using prototypical tasks have already been hinted at. Since they are easily explained, small, and self-contained, they can be solved relatively quickly. They lend themselves to simple objective outcome measures although one may also, with a little more work and time, also make interesting qualitative process observations. Since they do not require specialized extensive training, a large number of people can be given the problems meaning that a wide variety of proposed methods, tools and techniques can be tested. Furthermore, because they are relatively divorced from cultural and political entanglements, it is possible for investigators around the world to work collaboratively to determine effective treatments. This would problematic, for example, if one were to compare, say, architectural design firms in three different countries because the training, legal strictures, customs, and so on might differ so much as to overwhelm effects that are due to proposed methods or tools.

The main danger in using prototypical tasks is to imagine that such tasks are *equal to* complex, real-world design tasks and therefore to argue that a positive result found on such a task *implies* that the tool, method, or technique used is good for real world design. Just as drugs are tested first with mice and only if found effective and harmless later tested in clinical trials with humans, so to, we cannot presume that methods which impact prototypical tasks will necessarily be effective in the context of large-scale design problems. Even more likely, *a priori,* there may well be tools dealing with the interactions of design processes that may actually be useful in complex real world design tasks that are not especially valuable in improving performance on any single prototypical task. However, we need not be blind to such implications. If a tool is designed with cross-task or cross-phase coordination in mind, or if its purpose is to deal with the political and social contexts of design, then obviously we would not use simple prototypical tasks sa a proving ground (unless we could be clever enough to design a prototypical tasks that addresses such concerns). On the other hand, if the design rationale for a design method is, say, to help people become aware of their unstated assumptions and we cannot show it to be effective even on the "Two Boxes Problem" it may reasonably increase our skepticism with respect to such a claim.

GUIDELINES FOR USING PROTOTYPICAL TASKS

Many of the guidelines have already been implicitly mentioned above but basically, prototypical tasks must first of all be grounded in the problems found in real world design. Second, the inferences made on the basis of using such tasks must be limited to those aspects of design the task is meant to reflect and even then, the conclusions are tentative. Nonetheless, through a dialectic of study between prototypical tasks and the in-depth study of real world design efforts, more progress can be made more quickly than by only studying one or the other.

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A Participatory Design Understanding of Interaction Design

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ABSTRACT
In this paper I frame my past design research with the philosophical approaches of participatory design as outlined by Pelle Ehn in *Work-Oriented Design of Computer Artifacts*. The paper provides a series of related design techniques as exploration of interaction design methods and concludes by raising questions of methodologies research and evaluation.

Author Keywords
Participatory Design, Design Methodology, Interaction Design, Ethnography, Scenarios, Participatory Workshops.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Design methodology holds a special theoretical position that links understanding of design to practice. Design methodologies formulate philosophical understandings of design's relation to the world and seek in detail to link that understanding with the actuality of designing in the world. Fortunately, despite the specificity and rigor in formulating design methods, there is typically flexibility in both the theoretical and practical application of methods. Such flexibility can be seen as an allowance for the vagaries of practice in the practical sense, and in an exploratory manner it allows for design research to extend and further understand design through design methodology research.

This paper is an exercise in viewing my past design research projects through the lens of participatory design (PD). More specifically, the work will be framed by the theoretical and philosophical principles of participatory design as laid out by Pelle Ehn in his text, *Work-Oriented Design of Computer Artifacts* [5]. Namely, the phenomenological view of Heidegger, the linking of skill, expertise, and transformation as found in Marx, and the transposition of Wittgenstein's language games to design games.

WORK-ORIENTED DESIGN OF COMPUTER ARTIFACTS

This section is the briefest of introductions and overview of Ehn's seminal text, *Work-Oriented Design of Computer Artifacts*, which was published in 1988. While other texts preceding this provide an overview of PD [1], this book is among the first in-depth theoretical rationales for PD. It aims to emphasize the opportunities and constraints for industrial democracy, basing its findings on one of the most cited PD examples, the Utopia Project.

Ehn formulates a philosophical foundation of the design of computer artifacts through the ideas of Heidegger, Marx, and Wittgenstein. In laying the conceptual basis for PD he strongly critiques the Cartesian rationalism of systems design. Ehn argues that design is concerned with social and creative activity founded in our traditions, but aiming at transcending them by constructing alternative futures. He states: "The dialectics of tradition and transcendence – that is what design is all about" [5 p. 7].

Ehn's inquiry is interdisciplinary, or even transdisciplinary, for while acknowledging the dual importance of the natural and social sciences he states the need to move beyond the disciplinary boundaries: beyond natural sciences penchant for relegating "social effects" to being a non-scientific concern; and for social sciences to leave behind the "pure" position of observation and analysis.

Ehn's account includes a historical overview of the collective resource movement in Scandinavian design - an attempt to make the design process inclusive of trade union activities, and to reach the explicit goal of industrial democracy in design and use. Pragmatically, Ehn discusses a tools perspective for skilled workers and designers to design in cooperation computer artifacts as tools for skilled work.

PAST RESEARCH AND TEACHING

My research has been concerned with interaction design and methods. One thread of the research involves projects that prototype systems for play, social experiences, and learning. These include prototypes for ambient intelligence physical games [12] and museums as responsive environments [6]. Along another thread, I have been exploring the idea of *everyday design* [10]. That is the notion that every one of us designs in the course of living our lives. We exploit the materials around us, such as designed artifacts by appropriating them for different and new uses. These two threads of research intersect in the belief that future interactive systems need to be pliable, simple, and open to ongoing design in order to weave themselves meaningfully into our lives. In addition to research, the focus of my teaching has been in interaction design methods and industry-based participatory design classes.

A DESIGN METHODS APPROACH AND RESEARCH EXPLORATIONS

In the midst of designing, my approach is best understood as a set of emergent actions conditioned by reflexive awareness, what might be described as reflective practice [9]. At a more distant point of reflection, the approach is deeply informed and conditioned by the underlying ideas of participatory design. In fact, the explicit social and political goals notwithstanding, the philosophical foundation that Ehn describes can well serve as the conceptual underpinnings for a methodological understanding of interaction design. In this section, I will look at the recurring actions of *design ethnography, scenarios, participatory workshops*, and *prototypes*, components of an interaction design approach, through the lens of Ehn's PD. In addition, I will add relevant research issues in respect to each of the techniques that my colleagues and myself have explored, or what can broadly be described as methodologies research.

Design Ethnography: Understanding the actions and situations of people has been a critical starting point in many projects. Our approach to design ethnography has included informal studies of play [12], systematic inquiries into museums [11] (see figure 1), and lengthy ethnographic studies of design in the home [13] (see figure 1). Ehn sees beyond the political strategy of inclusion to "a cultural and anthropological understanding of human design and use of artifacts" [5 p. 5]. And so a focus on human *practice* is a central concern, as such "practice is our everyday practical activity" [5 p. 60]. Practice in Ehn's terms incorporates a Heideggerian understanding of phenomenological embodiment of skill and knowledge.

In our recent methodological research, we have incorporated embodied performance through informance design into part of the ethnographer's techniques of reporting [13]. This research into techniques and methods explores the adaptation of informance design to ethnography [2]. This adds to the incorporation of design techniques to new forms of reporting and representation in ethnography such as the use of pattern language [3].

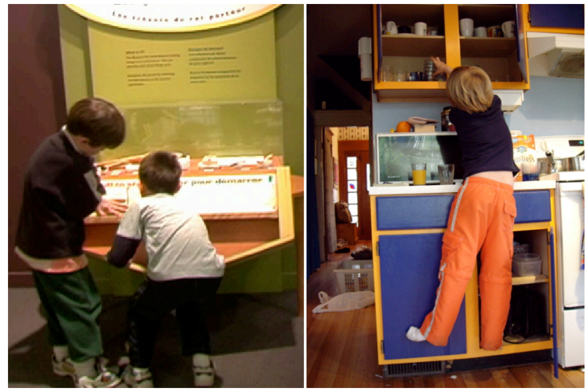

Figure 1 Design ethnography in a museum studying play, and in the home studying *Everyday Design*

Scenarios**:** Donald Schön argued that the design process is led by "frame experiments" [9]. Scenarios are exemplary frame experiments, the goal being to envision a possible outcome or future as a response to the design situation. The different forms of scenarios include, role-playing, storyboarding, scripts/narratives, sketches, videos, and interactive works. Our process utilizes scenarios often and typically early in the process (see figure 2). The scenarios acts as experiments and representations of future steps that becomes deconstructed through participatory design workshops. The link between scenarios and participatory workshops has been critical in our experience. Ehn stated "from a design point of view the challenge was to develop really participative design methods that allowed both professional users and professional designers to be creative in the design process. To this end we came to focus on what we called 'design-by-doing' methods, using simulations like prototypes, mock-ups, and organizational games, which allowed the graphic workers to articulate their demands and wishes in a concrete way… in the simulated future environment" [5 p. 18].

Figure 2 A video still from an early scenario for an adaptive audio museum guide

Figure 3 A participatory workshop exploring movement and gestures

Figure 4 A participatory workshop exploring narrative through simple games

Scenarios can be understood as documentaries of the future. Recently, we have been exploring the use of documentary film within a participatory approach as a representation of current and future situations. This work is on the heels of recent research on the role of documentary filmmaking as a tool in creating design personas [8].

Participatory Workshops: Workshops are another form of a "frame experiment," however based on participatory design. In our case, engaging participation of potential end-users and stakeholders in open but structured workshops, allows for exploration of design responses to situations generated by scenarios. Our workshops can be in response to other workshops and are therefore only planned one at a time in a responsive fashion. Each workshop arises out of the previous design inquiry. Ehn saw a pragmatic imperative along with a political one, "for democratic control and changes, [which] is only one side of the coin. The other is the role of skill and participation in design as a creative and communicative process" [5 p. 6]. Ehn utilized what he called "design games" as a method of enabling this process, transposing ideas of Wittgenstein's language games.

In our own approach, we have been exploring categorizing different workshop strategies. For example, in an ambient intelligent museum project a participatory workshop explored movement, gesture and its relation to space utilizing metaphors, such as "catching butterflies" as the concept to explore (see figure 3). In another project of an ambient intelligent multi-user game we explored narrative through simple game structures (see figure 4), in what might be considered a metonymic relationship between our workshop activity and workshop goals. Our categorizations are exploring literary theory concepts of metaphor, metonym, and allegory as representing different strategies, each with its own potential for outcomes.

Prototypes and prototyped environments: Prototypes and technical workshops serve an enabling and evaluative function. Early in our process they act generatively, supporting design responses with technology or exploring them through "wizard of oz" approaches. As the design outcomes emerge, components of the eventual system become prototyped and together are evaluated and help to evaluate the interaction through participatory workshops. In certain cases they satisfy a necessary requirement as in the case of a prototyped or simulated environment (in one instance we simulated in full scale a responsive version of an exhibition display within our lab, see figure 5) or as a stand-in for an eventual artifact component of an overall system as in our exploration of tangibles in an ambient intelligence environment. In PD, prototypes are central to the notion of *design-by-doing* and theoretically buttressed by Heidegger's concepts of *ready-to-hand* and *present-at-hand* in which a phenomenological presence is explored and understood. This is demonstrated in the oft-cited case of Ehn's use of cardboard and plywood mock-ups of workstations and printers in the case of a design workshop in the UTOPIA project [5 p. 335]. As Ehn stated, "artifacts can support both *communicative* and *instrumental* activities. Artifacts can *mediate* our activity towards other humans or towards *objects*" [5 p. 162].

The concept of prototypes and prototyped environments in

Figure 5 Large scale posters attached to frames were used to simulate a museum exhibition in full-scale in the lab

the context of design research raise issues of clarification and purpose that often are not addressed methodologically. Distinctions exist between prototype artifacts that are the outcome and subject of research; prototypes that are enablers in a participatory approach but do not serve as the outcome; and prototypes as necessary components or environments for simulating situated environments or what has been refereed to as "natural experiments" [7]. Often in the case of design research, combined uses of prototypes exist that are themselves outcomes and conditions for experimental research.

DISCUSSION

In an abstract for the National Science Foundation Workshop on Human-Centered Systems held in 1997, Ehn described three *worlds* of information technology design [4]: the objective, the social and the subjective. He continues that the languages of these worlds are very different. The objective world is rationalistic in its understanding of design, where quality is a question of prediction and control. The social world formulates an understanding of design through interpretation and communication, and quality is a question of ethics. The subjective world is centered on emotional experiences and creativity, and as one might expect, quality is a question of aesthetics.

Quality as described above is a central concern of design methodologies. An inspired understanding of design and embedding this understanding in practice is what leads to quality. Ehn provides a multi-dimensional notion of quality, which provides clues for a diverse understanding of the roles of methodologies. Equally importantly to design, it raises the issues of evaluation or validation of methodology along the varying axis of prediction and control, ethics, and aesthetics, all dependant on which *world* of information technology design one is in. Incorporating such epistemological framings could help support the range and types of methodologies research. Each is enabled by methods of validation and evaluation that are unique to the quality measurements each *world* values.

CONCLUSION

This paper presented a discussion of my past research through the lens of participatory design as laid out by Ehn in his seminal text, *Work-Oriented Design of Computer Artifacts*. The research discussed, included ambient intelligence environments for museums, multi-user games, and ethnographic inquiries into the concept of *everyday design*. I provided a brief introduction to *Work-Oriented Design of Computer Artifacts*, and discussed recurring components of interaction design in light of Ehn's PD. These components included *design ethnography, scenarios, participatory workshops,* and *prototypes and prototyped environments*. In addition, relevant methodological research explorations were introduced including the furthering of representational tools in design ethnography through the use of generative design techniques like informance design; the exploration of a participatory approach to documentary filmmaking as a form of representing current and future design situations; the use of literary theory concepts of metaphor, metonym, and allegory for describing strategies in participatory workshops; and the issue of distinguishing types and roles of prototypes in design research. The paper concluded with a discussion of different epistemological framings in information technology design that could be considered in addressing the question of evaluation and validation in design methodologies research.

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