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85 User Interface Design Principles for Interaction Design

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An Introduction to This Special Issue on Interaction Design Research in Human-Computer Interaction

Interaction design, as a field, has made great strides towards understanding and improving our interactions with technology products. From early explorations with the Web as an interactive structure, we now have reached the point where interaction design encompasses understanding the behavior of many types of technology products. The expansion of the field and associated conferences, publications, and journals are evidence of this growth. Topics for research and discovery include artifacts that are intelligent, autonomous, mobile, social, and embodied: artifacts and services that exist ubiquitously in the environment.

Design Issues last examined design research in 1999 (15:2). In planning this issue, we noticed that, despite the fact that many advances in design research related to interaction design and complex technology products have occurred, few have been published as such. Most of the published literature in this area has been relegated to process discussions in technical conference publications. Our goal for this issue was to provide a structure for reporting some of this new work, and to stretch the field of inquiry by focusing on emerging themes in interaction design, models of design research, the role of theory both in and outside of the field of design, and communicating the methods and processes inherent in our design research activities. We invited work that would represent how design researchers produce knowledge that effectively contributes to the design process, and becomes an integrating force for teams. We also hoped to better articulate how interaction design research is differentiated from the research produced by the other disciplines.

Contents of this Special Issue

In this issue of *Design Issues*, we present seven articles in the emerging area of interaction design research.

The editors of this special issue, Forlizzi, Zimmerman, and Evenson write on interaction design theory. In this article, we propose and describe a new model of interaction design research in HCI, based loosely on Frayling's concept of research through design. To formalize this model, we offer four criteria for distinguishing and evaluating interaction design research within HCI: process, invention, relevance, and extensibility.

Fallman, provides a context for the articles that follow with his view of interaction design theory. The author has provided a useful framework for design research in interaction design, differentiating three types of research activities: design practice, design exploration, and design studies; and the concept of loops, trajectories, and progressions for describing the development of design research work. The article and the framework should help design researchers to consider, and direct their work towards, industrial, academic, and societal problems at large.

The third article, on interaction design theory and the role of theory from other disciplines in influencing interaction design, is by Baranauskas and Bonacin. This paper proposes a framework for interaction design inspired by Organizational Semiotics theory. It frames design as a social process, involving a dialogue between problem and artifacts among the stakeholders in a design problem. A case study brings the framework to life.

The fourth article, by Kurvinen, Koskinen, and Battarbee, focuses on the social impact of technology in interaction design. Three fascinating field studies focusing on mobile communications technology use are described. The research presented in this paper is important as a design research case, a study of best practices, and a nascent framework for understanding reasons for and ways to prototype social interaction.

The fifth article, by Matthews, Stienstra, and Djajadiningrat, is both a case study and a study of how theories from other disciplines can influence interaction design. It first provides a comprehensive overview of issues and concepts influencing interaction design research, with a focus on play and interactive systems. The second half of the paper illustrates how theories can influence interaction design research, through a case study of interactive tiles, to understand the effect that such a system might have on play. In both the fourth and fifth articles, researchers had to understand and cope with the problems of deploying technology in real-world settings. These articles provide invaluable guidance for interaction design researchers attempting to assess concepts and build theories "in the wild."

The sixth article, by Ju and Leifer, provides a framework for understanding how to design interactions with technology products that require varying amounts of our attention. Cleverly using the example of an automatic door, first made famous in the essays of LaTour, the authors show how interactions can be developed that demand appropriate amounts of attention, and fit within well-defined social norms.

The seventh article is a best practices paper by Blair-Early and Zender. A systematic design inquiry was undertaken to discover the essential parameters of an interface, and critical design principles for the creation of interface designs. Integrating parameters and principles with an understanding of users, content, and form in a particular design problem provides a roadmap for interface and interaction design in both academia and industry.

Taken as a whole, these articles represent important themes in interaction design, developing theories to support these themes, and best practices and case studies to provide validity for these ideas. More interdisciplinary collaboration is needed between interaction designers, behavioral and social scientists, and technologists, and is essential in advancing interaction design research both within and beyond our field. Plenty of opportunities exist for these collaborations within and outside of the lab, and in academic settings, industrial settings, and society at large. In general, we see many opportunities for interaction designers in any setting, and believe that, as the landscape of interaction design research becomes more populated with examples, the field will continue to make significant advances.

Guest Editors
Shelly Evenson
Jodi Forlizzi
John Zimmerman

The Interaction Design Research Triangle of Design Practice, Design Studies, and Design Exploration

Daniel Fallman

1. Introduction

Interaction design takes a holistic view of the relationship between designed artifacts, those that are exposed to these artifacts, and the social, cultural, and business context in which the meeting takes place. While there is no commonly agreed definition of interaction design, its core can be found in an orientation towards shaping digital artifacts—products, services, and spaces—with particular attention paid to the qualities of the user experience.[1] To be able to deal with user experience—including physical, sensual, cognitive, emotional, and aesthetical issues; the relationship between form, function, and content; as well as fuzzy concepts such as fun and playability—a number of recent efforts have been made in the direction of establishing a better understanding of the role of the user experience in interactive systems design.[2]

Unlike the Human-Computer Interaction (HCI) community for instance, interaction design fully recognizes itself as a "design discipline" in that its ultimate objective is to create new and change existing interactive systems for the better.[3] There is a current plethora of departments, groups, and multidisciplinary labs dealing with interaction design that have their origins in such diverse places as computer science, HCI, anthropology, industrial design, informatics, and applied physics and electronics. Adding to the disciplinary confusion, each group typically also is configured as a multidisciplinary team.

Since the field of interaction design currently is growing rapidly in scope as well as importance,[4] both within academia and industry, there is an increasing need to also expand, further develop, and professionalize interaction design research. Refined models of interaction design research; embracing both what it currently is as well as pointing toward what it could be, arguably would be very useful tools in this process.

In this paper, we will introduce a model of interaction design research that has evolved at the Umeå Institute of Design, Umeå University, in Sweden in recent years, and which currently is guiding our interaction design research efforts as well as our Ph.D. education. Thinking about interaction design research in the way proposed by the model has helped us to keep up what we see

1 Jonas Löwgren, "How Far beyond Human-Computer Interaction Is Interaction Design?" *Digital Creativity* 13:3 (2002): 186–192; and Terry Winograd, "From Computing Machinery to Interaction Design" in *Beyond Calculation: The Next Fifty Years of Computing,* Peter J. Denning and Robert Metcalfe, eds. (New York: Springer-Verlag, 1997), 149–162.

2 Lauralee Alben, "Quality of Experience: Defining the Criteria for Effective Interaction Design," *Interactions* 3: 3 (1996): 11; Jodi Forlizzi and Katja Battarbee, "Understanding Experience in Interactive Systems," *Proceedings of the Conference on Designing Interactive Systems* (2004); and John McCarthy and Peter Wright, *Technology as Experience* (Cambridge, MA: MIT Press, 2004).

3 Daniel Fallman, "Design-Oriented Human-Computer Interaction," *Proceedings of Human Factors in Computing Systems Conference* (2003): 225–132.

4 John Zimmerman, Jodi Forlizzi, and Shelley Evenson, "Taxonomy for Extracting Design Knowledge from Research Conducted during Design Cases," *Proceedings of Futureground* (2004).

as three vital, external interfaces. First, it leads us to an interface with industry that has facilitated long-term collaborations and an exchange of people. Second, an interface with academia has encouraged staff and students at the design school—many of whom with no previous experience as part of a research community—to travel to conferences, workshops, and similar gatherings to meet others in the field, thus creating and upholding a network of peers vital to the school. Third, the model also reminds us of our interface with society at large, helping us think about interaction design research as having a voice in societal discussions, and in exploring and shaping possible futures (i.e., that industrial design is in fact not something that only concerns the industry).

2. The Model

In its very basic form, the model has the shape of a triangle. This triangle presents a two-dimensional space for plotting the position of a design research activity drawn up in between three extremes: "design practice," "design studies," and "design exploration."

While the actual methods, techniques, and tools being used in these activities can be quite similar, we argue that they are primarily different in *tradition* and *perspective.* These extremes are three different kinds of activities that we believe establish interaction design research as a discipline when taken together. We argue that combining these three activities (i.e., the contingency of the interaction design researcher to take on all three perspectives) distinguishes interaction design research from other disciplines with related interests, including Human-Computer Interaction (HCI), Computer-Supporter Collaborative Work (CSCW), Informatics, Computer Science, Anthropology, Sociology, Philosophy, and so on. The basic structure of our model is visualized as a triangle.

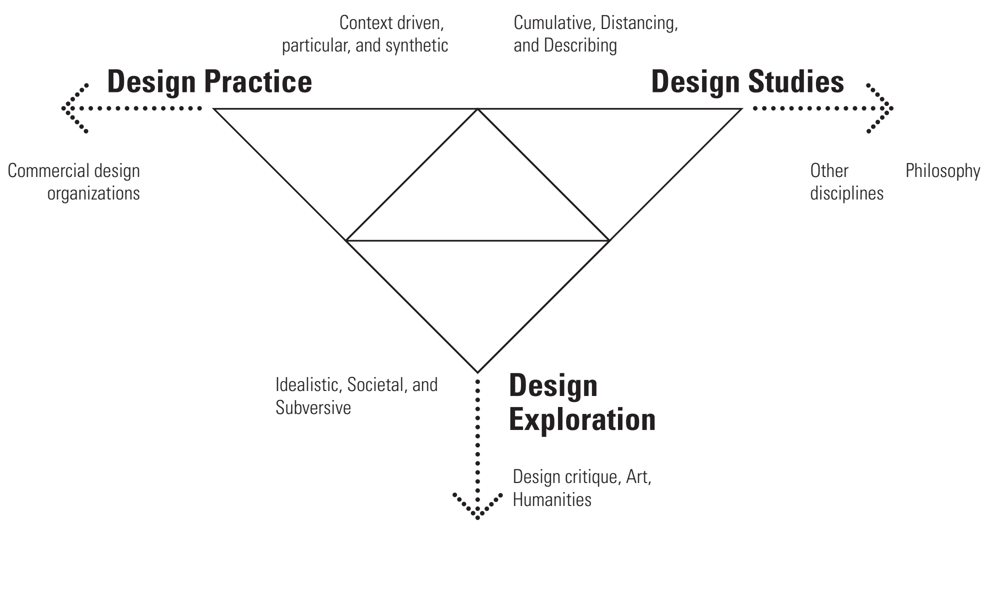

Figure 1
The model of interaction design research in its most basic form.

2.1 Design Practice

The activity area of design practice denotes the kinds of activities that interaction design researchers are involved in that are very close, and sometimes identical, to the kinds of activities they would undertake when practicing interaction design outside of academia, such as working for a commercial interaction design organization, a consultancy company working with client commissions, or an in-house design department.

We encourage our design researchers and Ph.D. students to take an active part in these practices. An important reason for this is to try to get at the tacit knowledge and competence that are involved in the discussions and critiques that eventually lead up to a final artifact.

In doing so, the interaction design researcher should not be part of the design team as an outside observer, first and foremost a researcher, but rather be part of the design team as a *designer.* The interaction design researcher thus becomes involved in actually putting things together, shaping the form of something new.[5] This process calls for a certain level of participation and commitment on the researcher's part[6]— involvement and participation in a team effort, and a commitment and engagement to build successful products and services—that is unobtainable by an outside observer.[7] While design practice clearly develops vital competence, tacit knowledge, and expertise among the designers involved; this combination of know-how and know-that often is confined within the individual designer and the design team due to an oral tradition in design work.[8]

In this activity area, our interaction design researchers become knowingly exposed to the nitty-gritty of interaction design practice, including being part of a multidisciplinary team; learning to communicate with managers, sales people, and engineers; working under strict and suddenly changing budget constraints; negotiating with clients and other stakeholders; and so on. Because it's a design discipline, it is important to realize that activities such as these are just as much part of what interaction design is as actually designing something hands-on.

There is, however, a vital ingredient in the model's activity area of design practice that must not be forgotten for the purposes of design research. When our interaction design researchers work in this area, they must do so with an explicit design research question in mind, or with the clear intent of forming such a question from their activities. The scope of such a research question can range from "reflective" (e.g., firsthand experience with how a particular design technique is used) to "proactive" (e.g., pushing a research agenda, and actively seeking to change how a specific design technique is used). If the goal of a particular project is to design a new, handheld control device for gaming, our interaction design researcher should be part of that project team the same way as everyone else in the

5 Harold G. Nelson and Erik Stolterman, *The Design Way: Intentional Change in an Unpredictable World* (Englewood Cliffs, NJ: Educational Technology Publications, 2002).

6 Richard Coyne, *Designing Information Technology in the Postmodern Age* (Cambridge, MA: MIT Press, 1995).

7 Thomas Nagel, *The View from Nowhere* (New York: Oxford University Press, 1986).

8 Donald Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983).

team, answering to the same constraints and rules as the rest of the team; and using his or her experience and competence to contribute to a successful result. But interaction design researchers also should have an appropriate design research question, reflecting on the work in which they are currently deeply involved. If successful, such reflection becomes an existential act that will help the field develop a kind of engaged knowledge[9] that may be inaccessible from an outside perspective.[10]

What is important here is that this research question needs not by necessity be a one-to-one match with the general direction of the specific design project. In the above example, for instance, the research question could be product semantics of artifacts aimed at teenagers or strategies to involve children in user studies—but the researcher just as easily could be interested in how a methodological technique (for instance a particular kind of brainstorming) is used in various stages in a design process, or the language game the multidisciplinary team develops to communicate. If the researcher has a proactive research agenda, he or she might employ the team and the content of the project to experiment with a particular kind of brainstorming. Naturally, a more active stance towards research is followed by a different kind of collaboration; one built upon mutual trust between the participants that may take years to achieve.

To summarize the design practice activity area, we see that it is primarily *synthetic* to its character. The interaction design researcher becomes involved and engaged in a particular design practice, but does so with an appropriate research question in mind.

2.2 Design Exploration

Design exploration seemingly is similar to design practice. It also is synthetic and proactive to its character in that the interaction design researcher is involved in bringing forth a product or a service. There are a number of important differences, however, that separate it from design practice, primarily due to the perspective from which the artifact is being constructed. In design exploration, the most important question is: "What if?"[11] As a sign of recognition, design exploration research almost always excels in what Schön calls "problem-setting,"[12] and Ehn[13] refers to as "transcendence" (i.e., exploring possibilities outside of current paradigms—whether these are paradigm of style, use, technology, or economical boundaries).

Yet another sign of recognition is the fact that the typical client in this activity area is the researcher's own research agenda. These projects often are self-initiated. Design in this area typically is driven neither by how well the product fits into an existing or expected future market, nor based on the observed needs of a group of users. Rather, design becomes a statement of what is possible, what would be desirable or ideal, or just to show alternatives and examples. Typically, work in this area also can be intended to provoke and

9 Ken Friedman, "Creating Design Knowledge: From Research into Practice," *Proceedings of International Conference on Design and Technology* (2000).

10 Daniel Fallman, "In Romance with the Materials of Mobile Interaction: A Phenomenological Approach to the Design of Mobile Information Technology," Doctoral Thesis, Umeå University (Umeå, Sweden: Larsson & Co. Tryckeri, 2003).

11 Donald Schön, *The Reflective Practitioner.*

12 Donald Schön, *The Reflective Practitioner*, and Donald Schön, "Designing as Reflective Conversation with the Materials of a Design Situation," *Knowledge-Based Systems* 5 (1992): 3–14.

13 Pelle Ehn, *Work-oriented Design of Computer Artifacts* (Falköping, Sweden: Arbetslivscentrum, 1988).

criticize a current state of affairs, such as the techno-critical digital art by Dunne and Raby.[14] In this sense, design exploration is a way to comment on a phenomenon by bringing forth an artifact that often in itself, without overhead explanations, becomes a statement or a contribution to an ongoing societal discussion. In this way, the activity of design exploration is clearly linked to some of the ideals of contemporary art, as well as to the interpretative attitude of many humanities disciplines. Design exploration thus creates the necessary space for the interaction design researcher to acknowledge and take seriously the issues of aesthetics.

While suppressed by functionalism for decades, we believe *aesthetics* to be a central concern for interaction design research. Understanding the role of aesthetics means being able to deal with issues of what is beautiful, harmonic, and fitting in the digital world; using synthetic processes that deal in a holistic way with the complex issues that make up a user experience including representation, sense perception, experience, conformance, and infringement, to tradition and culture, materiality, and genre.[15] Particularly when it comes to interaction design research, issues of aesthetics concern not only how something looks and feels, but also the aesthetics of the whole interaction including how something works, how elegantly something is done, how interaction flows, and how well the content fits in. Thus, design exploration is the activity area that allows the interaction design researcher to work with wholes—with complete, dynamic gestalts.

At the other end of the spectrum of design exploration (i.e., closer to traditional research), we have previously suggested that there also seems to be efforts in interaction design research that include synthetic elements as an important driving force but which, at the same time, seem to share many of the ideals of science.[16] For instance, this is the case when the kind of knowledge and user experience sought is the kind that cannot be obtained if design—the bringing forth of an artifact such as a research prototype—is not a vital part of the research process.

In summary, design exploration relies heavily on synthetic processes, but in doing so extensively uses the theories and alternative foundations for design. Design exploration often seeks to test ideas and to ask "What if?"—but also to provoke, criticize, and experiment to reveal alternatives to the expected and traditional, to transcend accepted paradigms, to bring matters to a head, and to be proactive and societal in its expression. Often driven by ideals or theory, design exploration provides what we see as a necessary space for aesthetic concerns in interaction design research. The artifacts coming out of design exploration often are societal in character, and sometimes even subversive.

14 Anthony Dunne, *Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design* (London: Royal College of Art, 1999).

15 Lev Manovich, *The Language of New Media* (Cambridge, MA: The MIT Press, 2001); and Richard Coyne, *Designing Information Technology in the Postmodern Age* (Cambridge, MA: MIT Press, 1995).

16 Daniel Fallman, "Design-Oriented Human-Computer Interaction," 225–232.

2.3 Design Studies

Design Studies is the third activity area of interaction design research, and that which most closely resembles traditional academic disciplines. The overall goal is to build an intellectual tradition within the discipline, and to contribute to an accumulated body of knowledge. This typically involves the design researcher in analytical work, and in taking part in and contributing to ongoing discussions about design theory, design methodology, design history, and design philosophy. This also is where influences from other disciplines are most visible, for instance working together with social scientists and experimental psychologists, and by directly referencing and adopting other disciplines' techniques, practices, and theories. The main arenas for this kind of work include conferences, workshops, and other gatherings, as well as locally by organizing reading circles and group discussions.

Most activities in this area strive to be part of "[a] systematic inquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems." [17] As such, design studies could be seen as "the sciences of the artificial." [18] But taking off from Simon's suggestion that "everyone designs who devises courses of action aimed at changing existing situations into preferred ones," [19] Ehn notes that, in order to learn what Simon has in mind with "preferred situations," one has to consider and integrate into any science of design typical subject matter of the human sciences. including issues of authority, power, control, and labor, and in what social and historical settings a particular design effort takes place.[20] The behavior of neither the individual designer nor the organization in which a design process takes place can be suitably captured by a science only of the artificial.[21]

Interaction design, like all design disciplines, thus resides in people, methods, processes, and artifacts. Activities in this area therefore are centered on issues such as "construction as a human activity" (i.e., the study of how designers work, think, and carry out design activity, including the study of the methods and processes designers use); "how designed artifacts perform their jobs" and how they work; "the study of the artifacts that are produced" (i.e., how an artificial thing appears and what it means),[22] following Cross's model of design epistemology, praxiology, and phenomenology.[23] To this, we might also add an interest in understanding the context of an artifact.[24]

To summarize this activity area, we note that it, unlike design practice, seeks the *general* rather than the particular, aims to *describe* and *understand* rather than create and change, and because of that often appears as *distancing* to its character rather than involving. Design studies, unlike both other activity areas, generally strive to form a *cumulative* body of knowledge.

17 L. Bruce Archer, "A View of the Nature of Design Research" in *Design: Science: Methods,* R. Jacques and James A. Powell, eds. (Guildford, UK: Westbury House, 1981).

18 Herbert A. Simon, *The Sciences of the Artificial* (Cambridge, MA: MIT Press, Third Edition, 1999).

19 Ibid.

20 Pelle Ehn, *Work-oriented Design of Computer Artifacts.*

21 Richard Coyne, *Designing Information Technology in the Postmodern Age.*

22 Nigan Bayazit, "Investigating Design: A Review of Forty Years of Design Research," *Design Issues* 20:1 (2004): 16–29.

23 Nigel Cross, "Design Research: A Disciplined Conversation," *Design Issues* 15:2 (1999): 5–10.

24 *Computers and Design in Context,* Morten Kyng and Lars Mathiassen, eds. (Cambridge, MA: MIT Press, 1997).

3. Moving In-between Activity Areas

In our use of the model, we believe the most interesting and rewarding results in interaction design research come not from taking a specific position in the model, but rather from moving or drifting in between different positions. While the actual methods, techniques, and tools that are being used in each of these activities can be quite similar at times, we argue that the activities primarily are separated in terms of perspective and tradition. Thus, moving in between different positions in the model is, more than anything else, a *change of perspective*—using a different set of goggles.

Acknowledging the three activity areas of design practice, design exploration, and design studies, and understanding how they differ in terms of perspective and tradition, is crucial for establishing interaction design research as a discipline. We argue that the ability to move in between all three areas in a controlled way distinguishes interaction design research from other research disciplines with related interests in interactive systems including Human-Computer Interaction (HCI), Computer Science, Informatics, Anthropology, Sociology, and Media Studies.

We believe that being able to move in between different parts of the model (i.e., dealing with all three perspectives and the tension that occurs between them) also is what makes interaction design research fresh, innovative, and unique.

To be able to discuss and elaborate further on tensions and movement in the model, we have introduced three concepts that together form a simple notation that can be used with the model: trajectories, loops, and dimensions.

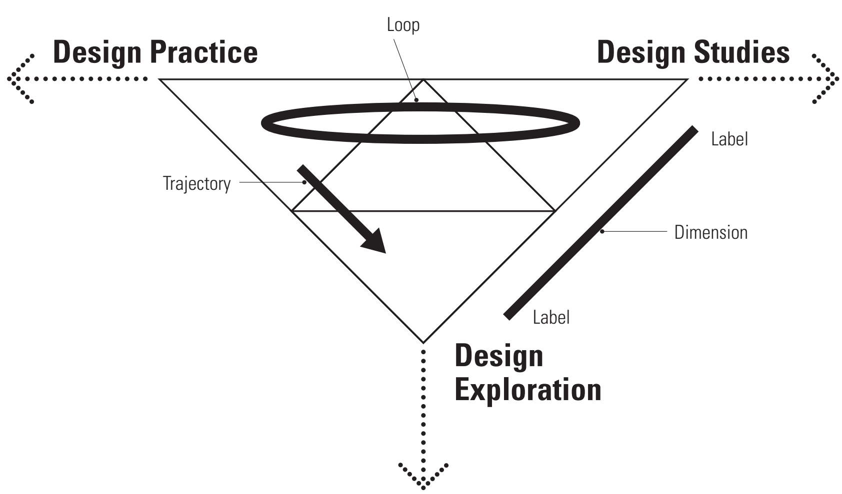

Figure 2
Trajectories, loops, and dimensions.

3.1 Trajectories

First, trajectories refer to either sought moves or unwanted drifting in between two or more activity areas in the model, and are drawn as simple lines with arrows to indicate direction. Trajectories also can take place inside of a single activity area, for instance, to indicate subtle changes and tensions occurring in a project.

We have found the notion of a trajectory to be a useful tool for making explicit what kind of perspective a certain project has, and what kind of quality measures, guarantors, and stakeholders we will face when moving in between different activity areas.

3.2 Loops

Loops, as the name suggests, are trajectories without either starting or end points that move in between different activity areas. As previously argued, loops are crucial in that they represent what sets interaction design research apart from other research: the ability to move freely between design practice, design exploration, and design studies. Loops are the notation we use to think about, plan for, and afterwards explain these movements.

As a general scheme, we set up most research efforts and Ph.D. student projects in the form of loops in between at least two of the activity areas. Since the activity areas denote a change in perspective more than a change in actual practice, loops should not necessarily be thought of as occurring sequentially in time. On the contrary, in a loop between design practice and design studies, for example, the two activities often transpire and feed into each other, rendering them almost inseparable. In design practice, a researcher takes part in a design practice project, typically working in a team with industry constructing an artifact. Wearing the design studies goggles, the researcher forms an explicit research question by reflecting on previous experiences, issues, and challenges arising in his or her current design practice project; and also by taking part in conferences and workshops, reading design research literature, discussing with colleagues, etc. With the research question in mind, the researcher is able to put on the design studies goggles to reflect on what is going on in the design practice project.

In our experience, explicitly drawing this complex process as a loop in the model seems to help people realize and think about what goggles they should be wearing and when. Similar loops can be drawn between design exploration and design studies, as well as between design practice and design exploration. In some cases, a loop can cover all three activity areas.

3.3 Dimensions

A dimension is a conceptual subset of the whole model that connects and creates a one- or two-dimensional continuum between the activity areas. Dimensions are what come to charge the whole model with meaning by creating tension between the different activity areas.

Unlike trajectories and loops that appear inside the triangle model, and represent our activities as interaction design researchers, we generally tend to draw dimensions outside of the actual model to stress that they are conceptual extremes. These end points are labeled with descriptive words or symbols.

While obviously there are an infinite number of dimensions one could think of, a specific issue discussed within the framing of a specific situation within a specific project usually limits the number of dimensions that are relevant to consider at that time. Using simple bipolar dimensions in this way has become a way for us to work with and charge our work with theoretical content in quite a practical way. For us, dimensions have become a very useful and powerful tool in which to introduce design theory to the discussion in a practical, situated, contextualized, and meaningful way.

As an example, one such extreme bipolar dimension we frequently use is between design practice and design exploration. Here, we usually label the first extreme with a dollar sign, describing the extreme corner of design practice—design in service of a client, that entails a whole set of concerns and limitations ultimately guided by how well the product performs at a specific market—and the extreme of design exploration as a sun appearing behind a cloud—ultimately guided by visions and ideals about how things should or could be (i.e., design as providing an alternative future).

A similar dimension can be found between design practice and design studies, but here between what is "real" and what is "true."[25] Design practice is about creation and change, to make things work and sell. To be able to do so, design practice needs to be *real,* in that it must pay attention to and often adhere to commercial aspects, cost, time to market, sales figures, other products in the market, an existing model line, user preference, and so on. The perspective of design studies on the other hand, again in its extreme form, is to seek to understand, explain, and predict—ultimately directed towards what is *true,* however as locally as that true may be.

A simple example may enlighten this very important difference in perspective of these two activity areas. While computer keyboards have always used the QWERTY layout of the early typewriters, when it was necessary to physically separate frequently used keys to prevent mechanical jams rather than to provide efficient user input of text. Research (seeking what is true) has shown repeatedly that many other layout models for keyboards, such as the Dvorak configuration, significantly increase typing speed after a short learning period. Alternative layout models for computer keyboards have done very badly in the market, however, so designers of keyboards (which need to be real) keep designing keyboards using the QWERTY layout. The main point here is that it is negligence neither on the part of the researchers nor the keyboard designers (i.e., not knowing what is true or what is real) that is the problem. Rather, it is a difference in fundamental *perspective* and *tradition* that sometimes

25 Harold G. Nelson and Erik Stolterman, *The Design Way.*

renders them incommensurable. While design studies may call attention to the fact that alternative keyboard layouts provide more efficient input, design practice typically needs to deal with the fact that QWERTY keyboards are what sell.

A number of dimensions and tensions such as these arise within the model. Some can be been adopted directly from design theory literature, including work by Nelson and Stolterman,[26] Ehn,[27] and Schön.[28] Other dimensions have been developed out of perceived differences in world-views among designers and researchers in and around the area, while a third source has been our previous experience in practice, research, and teaching. While far from a complete picture, a few of these dimensions are summarized below as examples of the kind of discussion that can come out of the model:

> *True—Real—Possible.* If design practice needs to be concerned with what is real and design studies with what is true, design exploration instead seeks to show what is possible; to show an alternative future; and to transcend current paradigms.
>
> *Judgment/Intuition/Taste—Analysis/Logic.* The form given to a specific element of, for instance, a logotype is due to the designer's judgment in the specific design situation—based on his or her competence, intuition, experience, and taste—in a complex conversation with the material.[29] This is quite dissimilar to design studies, where neither decisions nor results—at least in theory—can come from sources such as judgment, experience, and taste. If they did, almost by definition, they would not be regarded as scientific.
>
> *Tradition—Transcendence.* This dimension concerns the tension between extending and improving already established products or ways of working and thinking (i.e., rooting one's design in an existing tradition), and exploring a possible future by transcending (i.e., breaking down and going beyond) the boundaries of an existing design paradigm.
>
> *Particular—Universal—Ideal*. Design practice often deals with the ultimate particular. A specific design project has a set of requirements and constraints that are specific to the situation, and the outcome of the design project is a product or service that also is particular. An interaction design project may, for instance, result in a mobile phone that has a particular shape, a particular name, a particular brand, etc. (i.e., the ultimate particular). Design studies, on the other hand, often have less interested in the ultimate particular, but rather in what the general aspects, issues, and elements are shared by a group, or all, mobile phones. Third, design

26 Ibid.

27 Pelle Ehn, *Work-oriented Design of Computer Artifacts.*

28 Donald Schön, *The Reflective Practitioner.*

29 Donald Schön, "Designing as Reflective Conversation with the Materials of a Design Situation," 3–14.

exploration would be likely to pose another question altogether—what qualities would an ideal mobile phone embody?

Create/Change—Explain/Understand—Suggest/Provoke. Striving to create and change implies that design practice is a proactive activity of creation and intentional change. In design studies, the researcher instead aims to better understand a phenomenon to be able to explain and predict it. While design practice aims to change, and design studies aim to explain, design exploration—owing to its transcendental character—on the contrary often aims to suggest alternatives, problematize, criticize the current state of affairs, and provoke.

Client—Peers—Critics. The role of the guarantor (i.e., the body guaranteeing the quality and validity of the work), typically is quite different between the three activity areas. While design practice tends to emphasize the role of the client and various business goals in this process, design studies usually relies on peer reviewing to guarantee good quality. When it comes to design exploration, the answer is not straightforward. Other design fields such as architecture and graphical design have recognized design journals that publish design critiques. Such a tradition is yet to be established in the interaction design field.[30]

30 Olav Wedege Bertelsen and Soren Pold, "Criticism as an Approach to Interface Aesthetics," *Proceedings of Third Nordic Conference on Human-Computer Interaction* (2003).

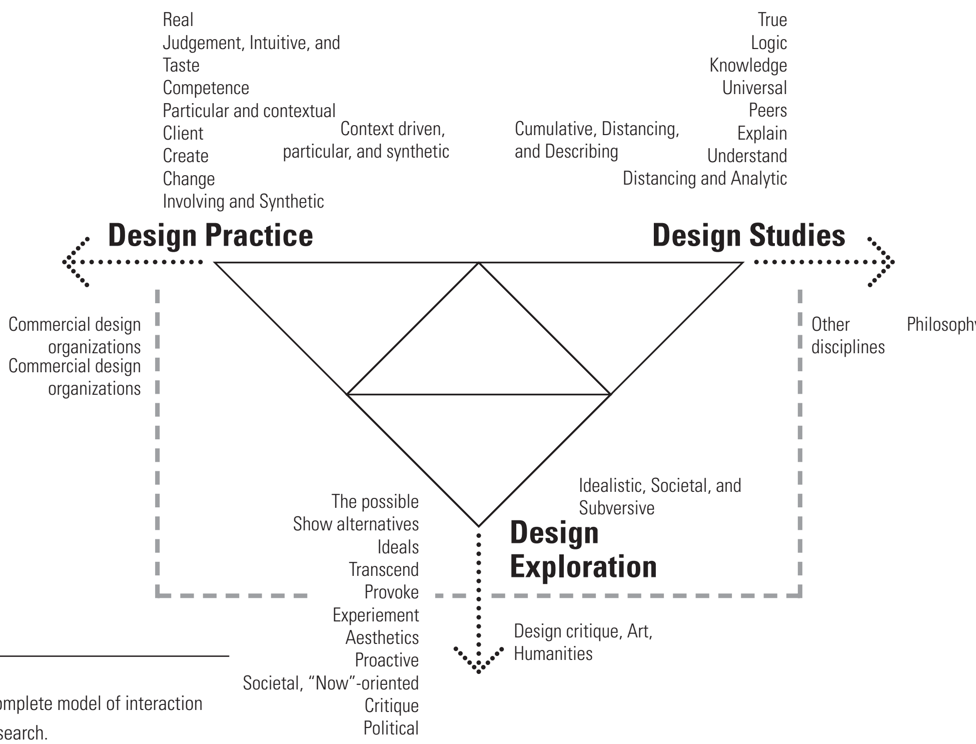

Figure 3
A more complete model of interaction design research.

4. Using the Model

How can the model presented in this paper be used in practice to stimulate reflection and discussion in the area of interaction design research? How does it related to other models of design and design research?

We have been using the model for a few years, exposing it on a regular basis to all design researchers and Ph.D. students. In this way, our use of the model has become more or less omnipresent, and has helped to form our understanding of design research, providing us with a common ground. Some of the ways in which we have found the model useful include:

- *Discussing specific design research projects.* The model also is useful for discussing projects when the design team is multidisciplinary, and may consist of members from collaborating companies and/or other academic disciplines.
- *Discussing longer design research efforts.* The model can be used as a background to discuss the layout and plan of a longer research commitment, such as a Ph.D. thesis.
- *Plot a research group's current projects.* What kind of projects are our group involved with at the moment?
  Is there a clear center of gravity in any of the three activity areas and, if so, is that a desirable situation?
- *Differentiate between quality measures.* Projects appearing in the three different activity areas all need to have different quality measures. When is a project successful? Who is the guarantor of quality?
- *Differentiate between various kinds of contributions and deliverables.* What kind of contributions can we as researchers expect to give, as well as expect others to provide? What should be regarded as satisfactory output from a given activity?

5. Situating the Model

The model presented in this paper has evolved over a number of years, and can be seen as an extension of our previous work and that of others. There is a current tendency in many disciplines, and not only the explicit design disciplines, of moving from more traditional forms of research studies—attempting to describe and understand—to proactive research, to strive to change and create something new. In HCI, for example, researchers are not primarily studying the usability of existing styles of interaction or interface solutions. On the contrary, one of the core activities in contemporary HCI is the design of novel technologies, often called "prototypes," which act as vehicles through which the researchers' ideas for novel and alternative solutions materialize. To shed light on this tendency, we earlier pointed out what we saw as two different kinds of conducts in HCI. First, we suggested "design-oriented research"—where research is the area and design the means—as a means of producing new knowledge by involving design activities in the research process. Here, design drives and propels research. Second, in "research-oriented design"—where design is the area and research the means—the creation of products, and in the process answering to the problems and real-world obstacles one encounters, is the primary objective. Research is what drives and propels design.[31] While this model sometimes has been interpreted in such a way, we never intended it to provide anything like a complete picture of a preferred situation when it comes to design research. On the contrary, it was meant to be a concrete tool to suggest, analyze, and discuss what appeared to be two competing and sometimes incommensurable traditions within the field of HCI.

There are a number of other models of interaction design and design research to which the model presented in this paper needs to be compared. While there is not space here to comment on all in detail, a few of these need special attention. We already have briefly mentioned Cross's[32] classification of design research as being primarily concerned with the three categories of "design epistemology," the study of how people design; "design praxiology," the study of design methods, techniques, and processes; and "design phenomenology," the study of the artifacts that come out of design processes. Several other models try to deal with the different kinds of inquiry that seems to exist in design research; acknowledging that design research seems unusual in being understood both as an intellectual discipline as well as an applied discipline. Friedman[33] suggests four areas that a progressive design research program needs to address; the philosophy and theory of design, research methods and research practices, design education, and design practice. In his overview of design research, Roth[34] discloses some of the different kinds of inquiry that seem to exist in design research from the very concrete and specific to the more conceptual, theoretical, and even philosophical and contrasts the use of qualitative and quantitative approaches. Buchanan's[35] classification scheme includes what he calls clinical, basic, and applied design research. Sato[36] notes that the interest of design research is twofold—in understanding the acts of design, and in understanding the subjects of design.

With the exception of these models and a few others, one of the largest current problems in design research in general—and possibly interaction design research in particular—is its failure to develop strong models (i.e., sustainable theory out of its own practice). Especially among designers, there sometimes is a tendency to place design on an equal footing with research (i.e., to say that design practice is more or less the same thing as research, and thus that such things as traditional theory construction in the field are not really necessary.

In relation to our model, the tradition and perspective of Cross's categories belong to the design studies activity area, since

31 Daniel Fallman, "Design-Oriented Human–Computer Interaction."

32 Nigel Cross, "Design Research: A Disciplined Conversation," 5–10.

33 Ken Friedman, "Creating Design Knowledge: From Research into Practice."

34 Susan Roth, "The State of Design Research," *Design Issues* 15:2 (1999): 18–26.

35 Richard Buchanan, "Wicked Problems in Design Thinking" in *The Idea of Design,* Richard Buchanan and Victor Margolin, eds. (Cambridge, MA: MIT Press, 1996): 3–20.

36 Keiichi Sato, "Perspectives of Design Research: Collective Views for Forming the Foundation of Design Research," *Visible Language* 8:2 (2004): 218–237.

they are describing their character, and suggests the research take on an observer's perspective. Some of the other models acknowledge the role of practice, but tend to regard design practice in terms of the clients of design research. In contrast, our model suggests that an important part of the design research process is allowing the researcher to change roles and perspectives (i.e., to step out of the scientist's view from nowhere).[37] Notwithstanding the need for proper studies in the categories above, we believe that allowing first-person perspectives to enter design research has the potential to provide findings unattainable with only an outside perspective, and thus add significantly to the overall quality and the relevance of design research.[38]

While most of the above-mentioned models point out the dialectics between what we call design practice and design studies, few seem to appreciate the third end of our triangle, design exploration. In contrast, we believe that the aesthetical and transcendental concerns this end of the spectrum represents are central in understanding design research, perhaps especially so for interaction design research because of its sometimes close resemblance to other, seemingly similar areas of research, such as HCI.

Furthermore, the efforts in the activity areas of design exploration and design studies reveal things about the nature of interaction design that appear to be unattainable from within design practice, since they provide alternative ways of approaching knowledge construction, ask a different set of questions, and give the design researcher very different perspectives. Taken together, however, we argue that thinking about research in interaction design in terms of going back and forth in between the three activity areas presented above provides some initial steps towards separating interaction design research from other kinds of research in the neighborhood of designing interactive systems.

6. Conclusions

Our model's emphasis on interaction design as a design discipline accentuates the importance of incorporating and addressing typical design questions such as the role of the client, the parallel emergence of question and answer, aesthetical issues, and design as about presenting possible futures into the scope of interaction design research.

One of the most rewarding effects of the model has been the way it has helped to establish a kind of pidgin language (i.e., steps towards a common ground) in our organization around issues of research in interaction design; inclusive of some kind of agreement about interaction design research means to us; why we have it; and what it could be. For us, this model has made people talk, challenged preconception, helped us see things, and stimulated discussions.

To conclude, we argue that a somewhat greater benefit of using this model is that it supports the three vital interfaces that we

37 Thomas Nagel, *The View from Nowhere.*

38 John McCarthy and Peter C. Wright, *Technology as Experience* (Cambridge, MA: MIT Press, 2004).

see as central to interaction design research, and that helps to distinguish what is unique about interaction design research compared to other communities of practice in and around the area of interactive systems design.

First, the activity area of design practice provides the "interface towards industry." This interface recognizes and acknowledges long-term collaborations, joint projects, and the exchange of people between interaction design research and industry. It also is important because it directly links interaction design research with industry-relevant questions and concerns. This interface thus increases the chances of upholding and starting new collaborations; finding new industry partners through a larger network of contacts; the opportunity for industry-financed doctoral students; and as an aid to students in finding external exam projects, internships, and eventually jobs in industry.

Second, the activity area of design studies provides "an interface towards academia." Conducting work in this area means building an academic and intellectual tradition within the organization. This entails making space for reflections in some kind of structured way on one's activities; organizing reading circles and seminars; and opening up arenas for theoretical, methodological, and philosophical discussions to take place—as well as traveling to conferences, workshops, and similar gatherings to meet others in the field; to learn what is new and coming; and to uphold a network of contacts and peers. Naturally, this interface also is where influences from other disciplines enter into the field. The interface towards academia thus grounds interaction design research within the larger topology of research disciplines.

Third, design exploration provides "an interface towards society at large." Based on our experience, there appears to be inherent power in materializing or "thingifying" one's ideas, sketches, and thought experiments into dynamic artifacts, whether or not these turn out to be products, services, or spaces; and communicate these not only to academic groups and industry, but also to use whatever channels are available to become a voice in societal discussions and thus in shaping the future.

Crafting a Place for Interaction Design Research in HCI

Jodi Forlizzi, John Zimmerman, and Shelley Evenson

Introduction

In recent years, a number of academic institutions around the world have worked to integrate design practice and thinking with engineering and behavioral science in support of Human-Computer Interaction (HCI) education and research. While the HCI community generally has been enthusiastic about the benefits that design can bring to this developing interdisciplinary field, tension exists around the role of design in research, because no agreed upon model for a design research contribution exists. Over the last three years, we have undertaken an inquiry to understand the nature of the relationship between interaction design and research in HCI, and to discover and invent methods for interaction designer researchers to more substantially collaborate and contribute to HCI research.

Through our inquiry, we learned that many HCI researchers' commonly held view of design is focusing on the surface structure of products. This echoes Blevis et al's claim that most people in the world view design as adding decoration.[1] This limited view of design makes it difficult for HCI researchers to articulate how they would like designers to participate in research. In addition, the interaction design community lacks a unified vision of what design researchers can contribute to HCI research, and to interaction design at large. The current lack of design participation in HCI research represents a lost opportunity to benefit from the added perspective of design thinking in a collaborative, interdisciplinary research environment. The HCI research community has much to gain from the addition of design thinking; a design perspective that employs a holistic approach to addressing under-constrained problems, and that adds a needed counterpoint to the reductionist approach favored by the scientists and engineers.

To address this situation, we have developed a new model of interaction design research in HCI intended to allow designers to participate more evenly. While this is not the only way for designers to participate in HCI research, we wanted to create a method that allowed designers to make a design contribution without imitating the methods of other disciplines. Our model builds on Frayling's[2] idea of "research through design," stressing how interaction design-

Acknowledgements
We would like to acknowledge the Human-Computer Interaction Institute at Carnegie Mellon University for generously funding this research.

1 Eli Blevis, Youn-Kyung Lim, and Erik Stolterman, "Regarding Software as a Material of Design," *Proceedings of Wonderground* (Lisbon, Portugal: Design Research Society, 2006).

2 Christopher Frayling, "Research in Art and Design," *Royal College of Art Research Papers* 1:1 (1993): 1–5.

ers can engage wicked problems.[3] In addition, we also have created a set of criteria to evaluate this type of research contribution. This approach stresses a transformation of the world from its current state to a preferred state through the creation of design artifacts that provide concrete framings of messy problems. In addition to bringing design thinking to HCI research, this model offers an easy way to transfer research findings to the HCI practice community.

In the next section, we present a brief overview of the evolving relationship between design and HCI. We then present five models of design research that currently exist within HCI. And we present our model, which is intended to complement, rather than replace, currently existing models. Finally, we provide a set of four criteria for those in the community to evaluate an interaction design research contribution that follows this model.

The History of Design within HCI

The field of HCI emerged out of collaborations between psychologists and engineers.[4] Early contributions such as the Differential Analyzer, a large-scale log computer that used mechanized pens to output text, provided feedback from the computer that people could more easily understand and process. The PDP-1, an industrial computer featuring a display for feedback and a keyboard, light pen, and paper tape reader for input also was an advance, framing the interaction in terms of both input and output. Englebart's invention of the mouse—a graphic input device that remains the standard today—and Nelson's early work in the area of hypertext both brought consideration of the human into computing. These key advances in humanizing the interaction between people and computers created the first opportunities for the HCI community to consider the need for collaboration with designers.

Early HCI researchers and developers recognized a need to distinguish interfaces for programmers, used to develop and test an application, from those for users, needed to understand how to operate the application. The issue of how people would access and control early computers created the first opportunities for design where the term "design" was used synonymously with usability engineering: "... the process of modeling users and systems and specifying system behavior such that it fitted the users' tasks, was efficient, easy to use and easy to learn."[5] This emerging focus on users as separate from developers and operators created an opportunity for cognitive psychologists to play an increasingly important role. Stu Card and Tom Moran's *The Psychology of Human-Computer Interaction* summarized the literature on human information processing, and offered a model of human processing that could be applied to predict how people would both learn and efficiently interact with interfaces.[6]

3 Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4:2 (1973): 155–166.

4 Richard W. Pew, "Evolution of Human-Computer Interaction: From Memex to Bluetooth and Beyond" in *The Human-Computer Interaction Handbook,* J. A. Jacko and A. Sears, eds. (Mahwah, NJ: Lawrence Erlbaum Publishers, 2003), 1–17.

5 Ibid., 1.

6 Stu Card, Thomas P. Moran, and Allen Newell, *The Psychology of Human-Computer Interaction* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983).

In the late 1970s, when command line interfaces were standard, the first notions emerged that some user-oriented design principles might be applied to the design of the screen.[7] At this time, design guidelines and style guidelines gradually emerged. This advance helped the computer move more rapidly into work environments, and shifted the use of computers from an operator model with a focus on making a machine work, to a worker model with a focus on using the computer as a tool to get work done. This transition created a need for anthropologists to join in the HCI collaborations. HCI researchers and developers needed their skills at understanding the culture of the office environment to help inform the design of computing systems that could be successfully integrated into office culture and work practice. The interpretive methods used by anthropologists provided the first example of nonscientific research in HCI. However, the kind of research contributions anthropologists can make have been limited by the research community. In general, anthropologists must frame their research in terms of implications for the design of technology instead of implications in terms of theories of human behaviors.[8]

The invention and rapid acceptance of graphical user interfaces helped to increase the role that designers, particularly graphic designers, played in the HCI community. This advance made the computer much more accessible to people, helping the computer spread from the office to many other contexts. Suddenly, many HCI practitioners found themselves working with designers; however, the two groups had radically different ways of approaching problems. Jonas Löwgren coined the term "creative design" to distinguish the ideation and problem-framing used by designers from the engineering approach of developing to a predefined specification.[9] In creating this term, he argued for a culture change to allow the benefits of design thinking to have a greater influence on the design of interactive products.

The next huge advance for designers undoubtedly was the emergence and meteoric acceptance of the World Wide Web. This huge collection of interconnected pages that included links, buttons, dropdown menus, applets, and multiple paths through a given set of information required the skills of information designers and newly minted interaction designers. Within a few years after its invention, almost all companies felt the need to have a digital presence on the Web, creating huge opportunities for designers to apply their communication skills. At first, much of the content on the Web consisted of print material simply ported to an electronic form. But fairly quickly, entirely new classes of applications and interactions emerged such as online shopping, online banking, project pages for coordinating work activities at multiple locations, wikis, social networking applications, etc. Today, almost all HCI practitioners find themselves working collaboratively with designers in the development of digital products and services.

7 Peter Wright, Mark Blythe, and John McCarthy, "User Experience and the Idea of Design in HCI," *Lecture Notes in Computer Science,* Stephen W. Gilroy and Michael D. Harrison, eds. (Berlin and Heidelberg: Springer, 2006), 1–14.

8 Paul Dourish, "Implications for Design," *Conference on Human Factors in Computing Systems* (New York: ACM Press, 2006): 541–550.

9 "Methodology to Software Development," *Designing Interactive Systems* (Ann Arbor, MI: ACM Press, 1995), 87–95.

Recent developments in mobile computing, contextually aware devices, and intelligent environments have given weight to a transition from the HCI's early obsession with usability to the social and emotional impact products have, and their ability to improve people's lives. This new design space, often referred to as "experience design," has helped to increase the influence of designers in the HCI product development process. Designers are increasingly playing a more important role, as witnessed by new academic conferences and publications focused on design and interaction design in HCI, an increasing number of advocates for design within the HCI community, and the movement to integrate design into HCI education.

Models of Design Research in HCI

While the role of design continues to increase in the HCI practice community, design as a research discipline has had less impact. Today, five distinct models of design research are known in the HCI research community: project research, design methods, pattern finding, design as research service, and critical design.

In casting HCI as a design practice, Daniel Fallman created the term "research-oriented design" to describe the upfront research HCI practitioners and interaction designers do to inform their design process.[10] This term describes the user-centered design approach generally applied in HCI practice through methods such as contextual inquiry,[11] or in the construction of personas.[12] Similar to Buchanan's idea of "clinical design research"[13] and to our previous work on opportunities for design cases to produce knowledge,[14] this type of research in the HCI community is limited to the ethnographic styled or participatory work done before the design of any artifacts. While the HCI research community understands this model, it is viewed strictly as design practice, and not considered a research contribution because the focus is on the development of a commercial product, not the production of knowledge.

Probably the most recognized model of design research by the HCI research community is the development and evaluation of new design methods intended to improve the process of developing interactive products. Examples include methods for the upfront research in a design case such as contextual inquiry and the personas mentioned above, and the increasingly popular cultural probes;[15] methods intended to increase empathy between designers and users including bodystorming[16] and experience prototyping;[17] and methods intended to extend the creative ability of designers such as interaction relabeling[18] and transfer scenarios.[19] An important role for design researchers to play is in the development of new methods. However, this method represents the only research contribution most HCI research venues will accept for publication, and thus severely

10 Daniel Fallman, "Design-Oriented Human-Computer Interaction," *Conference on Human Factors in Computing Systems* (Fort Lauderdale, FL: ACM Press, 2003): 225–232.

11 Hugh Beyer and Karen Holtzblatt, *Contextual Design* (San Diego, CA: Morgan Kaufmann Publishers, 1998).

12 Alan Cooper, *The Inmates Are Running the Asylum* (Indianapolis, IN: Macmillan Publishing Co., Inc., 1999).

13 Richard Buchanan, "Design Research and the New Learning," *Design Issues* 17:4 (2001): 3–23.

14 John Zimmerman, Shelley Evenson, and Jodi Forlizzi, "Discovering and Extracting Knowledge in the Design Project," *Future Ground* (Melbourne, Australia: Design Research Society, 2004).

15 Bill Gaver, Tony Dunne, and Elena Pacenti, "Cultural Probes," *Interactions* (1999): 21–29.

16 Marion Buchena and Jane Fulton Suri, "Experience Prototyping," *Designing Interactive Systems* (New York: ACM Press, 2000), 424–433.

17 Ibid., 424–433.

18 John Partomo Djajadiningrat, William W. Gaver, and J. W. Fres, "Interaction Relabeling and Extreme Characters: Methods for Exploring Aesthetic Interactions" in *Designing Interactive Systems* (2000): 66–71.

19 Sara Ljungblad and Lars Erik Holmquist, "Transfer Scenarios: Grounding Innovation with Marginal Practices," *Proceedings of the Conference on Human Factors in Computing Systems* (San Jose, CA: ACM Press, 2007).

limits opportunities for designers to participate in HCI research. It does not facilitate the application of design thinking to the problems faced by the HCI research community.

Recently, the HCI research community has recognized the use of pattern languages as an area of design research.[20] This interest stems from the tremendously popular 1995 book *Design Patterns: Elements of Reusable Object-Oriented Software,* which documents a small set of software development design patterns commonly found in object-oriented programming.[21] In general, this topic has been explored as a design method with researchers investigating how to best apply it in the interaction design space.[22] In addition, researchers have engaged in pattern finding. For example, they have documented the emerging patterns and documented these in a book to aid practitioners in the design of Web sites.[23]

Recently, HCI researchers have been exploring how design patterns can be extended to become pre-patterns.[24] One of the challenges in the interaction space is the rapid emergence of new classes of products and services such as smart environments and mobile computing. Generally referred to as "ubiquitous computing," researchers have explored the development of pre-patterns, indications of the emergence of design patterns by examining proof of concept prototypes. Designers using these pre-patterns to inform designs in the ubiquitous computing space have found that they help to reduce usability problems.[25] This work of pattern finding represents a connection between design research and HCI research, but the practice of pattern finding does not in itself require expertise in design thinking.

For many years, industrial research labs have employed interaction designers to work in the service of researchers. Designers work on research teams, engaging teammates in problem-framing exercises to help the team to both ground their research in terms of user needs and to frame the research around a preferred state it helps to achieve. In addition, designers working on these teams develop prototypes intended to communicate the value of the research contribution to stakeholders such as other researchers, product managers, and executives within the company.[26] At the CHI conference in 2006, the premiere venue for HCI research, one paper argued that designers working in this capacity employ a process of rationale judgments in contrast to the belief that designers employ "black magic."[27] The intention was to convince researchers that bringing designers into a research project would not corrupt the contribution. While recognized as a role that designers can play in HCI research, the work really is more about bringing design practice into HCI research, and does not provide an opportunity for designers to shape and drive the focus of the research.

20 Christopher Alexander, Sara Ishikawa, Murray Silverstein, Max Jacobson, Ingrid Fiksdahl-King, and Angel Schlomo, *A Pattern Language: Towns, Buildings, Construction* (Boston: Addison-Wesley, 1977).

21 Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software* (Boston: Addison-Wesley, 1995).

22 Thomas Erickson, "Lingua Franca for Design: Sacred Places and Pattern Languages," *Designing Interactive Systems Conference Proceedings* (New York: ACM Press, 2000): 357–368.

23 Douglas K. van Duyne, James Landay, and Jason I. Hong, *The Design of Sites: Patterns, Principles, and Processes for Crafting a Customer-Centered Web Experience* (Boston: Addison-Wesley, 2002).

24 Eric S. Chung, Jason I. Hong, James Lin, Madhu K. Prabaker, James A. Landay, and Alan L. Liu, "Development and Evaluation of Emerging Design Patterns for Ubiquitous Computing," *Designing Interactive Systems Conference Proceedings* (New York: ACM Press, 2004): 233–242.

25 T. Scott Saponas, Madhu K. Prabaker, Gregory D. Abowd, and James A. Landay, "The Impact of Pre-Patterns on the Design of Digital Home Applications," *Designing Interactive Systems Conference Proceedings* (New York: ACM Press, 2006): 189–198.

26 Tracee Vetting Wolf, "The Role of Design in Research," *HCI Research Seminar* (2004) Carnegie Mellon University, Pittsburgh, PA.

27 Tracee Vetting Wolf, Jennifer A. Rode, Jeremy Sussman, and Wendy A. Kellogg, "Dispelling Design as the 'Black Art' of CHI," *Proceedings of the Conference on Human Factors in Computing Systems* (New York: ACM Press, 2006): 521–530.

Finally, critical design, where design researchers play the role of a social critic, recently has gained a foothold in the HCI community.[28] Designed artifacts such as the Drift Table, a coffee table designed to support interaction where the designers have purposely avoided specific tasks a user might complete, work to expose the HCI community's obsession with task-specific work.[29] While critical design projects traditionally have had little success in gaining access to mainstream HCI research publications, recently some have had success framing themselves as research methods to gain insight into how end-users will react to technology.

These current research models provide some opportunities for design research in HCI practice, but few opportunities for research collaborations in the HCI research community. In addition, these models, with the exception of critical design, do not allow designers to participate from their position of strength, from their application of design thinking; to address problems and frame problems.

A Model of Interaction Design Research within HCI

Based on our synthesis and analysis of the literature review presented in the previous section, and on an iterative process of design and evaluation with researchers in HCI, we have developed a new model for interaction design research in HCI that advances Frayling's "research through design" concept.[30] In following this model, interaction design researchers focus on making the *right* thing; making transformative artifacts that move the world from the current state to a preferred state. The model depicted in Figure 1 shows how interaction design researchers engage wicked problems found in HCI. These problems arise from groups of phenomena, rather than single phenomenon in isolation. They have too many dynamic and interconnected constraints to accurately model and control using the reductionist approach found in science and engineering. Instead, our model asks researchers to select the appropriate placements:[31] lenses through which to view and constrain the problem, and with which to construct transformative artifacts. This model, with its focus on artifacts, builds on Cross's concept of design knowledge residing in the product.[32] The artifacts generated during interaction design research represent a specific framing of the problem, and are situated among other research artifacts that may require different lenses for approaching the problem. The artifacts serve as catalysts for continued discourse in the community. After a series of artifacts have been generated, they can be analyzed in order to understand approaches that have been taken in addressing common problems. Ultimately, patterns begin to emerge from these artifacts.

28 Anthony Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (Basel, Switzerland: Birkhäuser, 2001).

29 William Gaver, Phoebe Sengers, Tobie Kerridge, Jofish Kaye, and John Bowers, "Enhancing Ubiquitous Computing with User Interpretation: Field Testing the Home Health Horoscope," *Conference Proceedings on Human Factors in Computing Systems* (San Jose, CA: ACM Press, 2007).

30 Christopher Frayling, "Research in Art and Design."

31 Richard Buchanan, "Wicked Problems in Design Thinking," *The Idea of Design,* Victor Margolin and Richard Buchanan, eds. (Cambridge, MA: MIT Press, 1995), 3–20.

32 Nigel Cross, "Design Research: A Disciplined Conversation," *Design Issues* 15:2 (1999): 5–10.

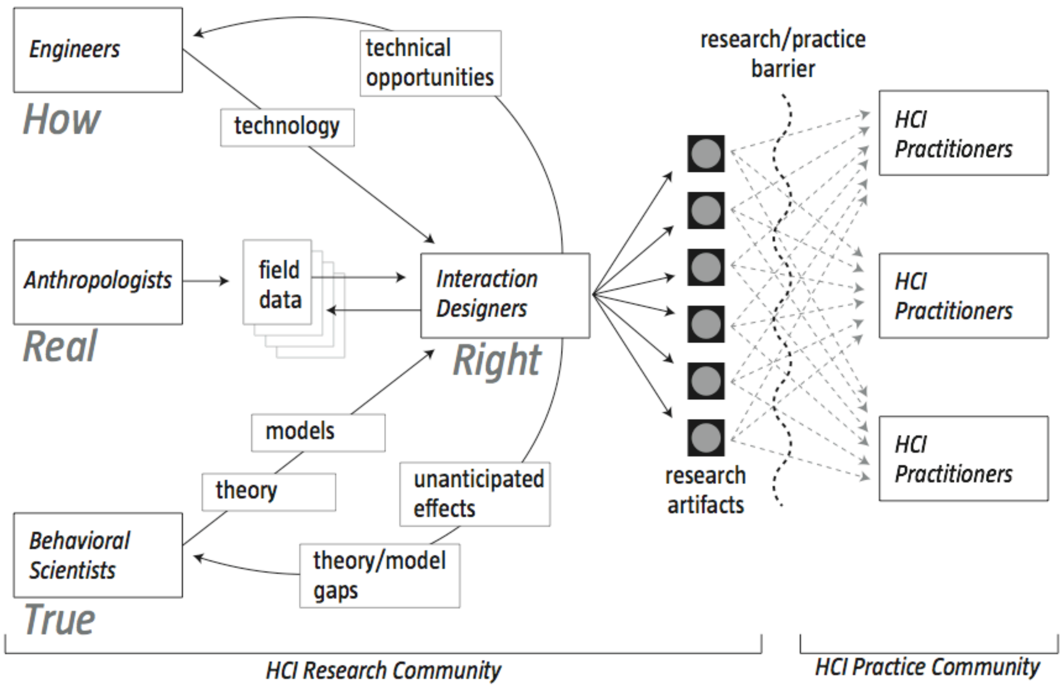

Figure 1
A model of interaction design research in HCI.

Our model allows interaction designers to integrate "true" knowledge in the form of models and theories from human scientists with "how" knowledge in the form of technical opportunities demonstrated by technologists. Design researchers perform explorations in the wild, grounding their explorations in "real" knowledge. Through an active process of ideating, iterating, and critiquing potential solutions, design researchers continually reframe the problem in their attempt to make the "right" thing: a concrete problem framing and articulation of the preferred state.

The HCI community can benefit from a research through design approach in a number of ways. First, this type of research can provide engineers with information about what to build. Second, it can provide human scientists with indications of where important gaps exist in their theories and models. Apple's Guides project provides an example.[33] In this project, researchers wanted to address the emerging problem of navigation in large, multimedia databases, so they constructed a full system that used black-and- white images of characters from different historic periods to work as visual navigational guides for users. However, when they evaluated this system, they noticed that people interpreted the content not as encyclopedia content, but as the opinion of the visual guide. By focusing on the construction of the whole system, the researchers identified an unanticipated social effect for the behavioral community to explore, and provided motivation for the engineers to construct systems that could support embodied computer agents.

33 Tim Oren, Gitta Salomon, Kristee Kreitman, and Abbe Don, "Guides: Characterizing the Interface," *The Art of Human-Computer Interface Design*, Brenda Laurel, ed. (Reading, MA: Addison-Wesley, 1990), 355– 365.

The artifacts produced by this model are concrete embodiments of theoretical and technical opportunities. They also serve as channels for the transfer of research knowledge to the community of practice. For educators, artifacts serve as ways of helping students understand how design activity unfolds. In design research, artifacts describe a vision of what might be; increasing the chance of knowledge transfer to the research, practice, and education communities. Artifacts teach the practice community how to more easily observe the value of different theories, models, and technology; and this can motivate them to follow the threads back to the original research that might most impact their work.

Our model adds an additional method to the five design research roles described above that is particularly suited for interaction design researchers working in HCI research, and allows design researchers to work more as a collaborative equal with other HCI researchers. An obvious criticism of this model is how design researchers using it can distinguish their contributions as research and not as practice. This is a concern raised by Nigel Cross, who does not consider normal works of practice to be research contributions.[34]

We differentiate research artifacts from design practice artifacts in two important ways. First, the goal of interaction design research is to produce knowledge for the research and practice communities, rather than make a commercially viable product. Therefore, research projects that take this research through design approach will likely de-emphasize certain perspectives in framing the problem, such as the detailed economics associated with manufacturability and distribution, the integration of the product into a product line, and the effect of the product on a company's identity, etc. In this way design researchers focus on making the *right* things, while design practitioners focus on making *commercially successful* things.

Second, research contributions should be artifacts of invention, representing novel integrations of theory, technology, needs, and context rather than incremental modifications to products that already exist in the research literature or commercial markets. Novelty makes particular sense in the interaction design space of HCI. Meteoric technological advances in hardware and software result in aggressive invention of novel products in HCI and interaction design domains that are not typically experienced in other design domains. For example, while appliance designers might find themselves redesigning a refrigerator to meet the changing needs of a family, interaction designers more likely would find themselves inventing whole new product categories to serve these families.

Our model of design research allows interaction design researchers to excel at studying the world and making artifacts intended to affect change. It represents a new channel to illustrate

34 Nigel Cross, "Designerly Ways of Knowing: Design Discipline versus Design Science," *Design Issues* 17:3 (2001): 49–55.

how the power of design thinking can be used in a research context. As a result, design researchers make their own revolutionary contributions, rather than copying the methods of other disciplines as a means of justifying a research contribution.

Criteria for Evaluating Interaction Design Research within HCI

We have illustrated how the research through design approach is a viable means for making contributions to the evolving landscape of design research. Yet within the interaction design and HCI research community, we have yet to agree upon a standard for what research through design is, or what might comprise a high-quality contribution. As a result of our research, synthesis, and analysis, we propose a set of criteria, or lenses, for evaluating a research contribution in interaction design. These are process, invention, relevance, and extensibility.

Process

The design process is a critical element in judging the quality of an interaction design research contribution. Simply stated, reproducing the same design process cannot be expected to produce the same results. This idea has been discussed in the domain of interface design and software engineering, where the process of undertaking interface design is likened to craft.[35] Rather than replicability, part of the evaluation of the work is to understand the rationale for the selection of given methods, and the rigor with which these methods are applied. Therefore, when interaction design researchers document their methods, they must do so with enough detail so that a particular design process can be replicated. In addition, a rationale should be provided for why specific methods were selected and used.

Invention

A significant invention must be discovered as an outcome of the interaction design research. Invention is defined as addressing a specific situation through a novel integration of subject matters. In articulating a contribution as an invention, the interaction design team must undertake an extensive literature review, and discuss in detail how advances in technology contribute to the invention. It is here that details about technical opportunities are communicated to engineers and computer scientists in the HCI research community, providing information and guidance on what to build.

Relevance

While scientific research has a focus on validity, interaction design research has a focus on relevance. In engineering, validity often takes the form of a clear performance increase or in the technical functionality of a contribution. In human (behavioral and cognitive)

35 David Wroblewski, "The Construction of Human-Computer Interfaces Considered as a Craft," *Taking Software Design Seriously*, John Karat, ed. (Boston: Academic Press, 1991), 1–19.

science, validity takes the form of an experiment that disproves the null hypothesis. In both cases, work is archived in a way that peers can reproduce both methodology and results.

However, this approach makes less sense for interaction design's research through design approach. As stated earlier, there can be no expectation that two interaction designers who have been given the same problem will produce identical or even similar outcomes. Therefore, relevance, rather than validity, is the second criteria for interaction design research. Validity constitutes a shift from what is *true* to what is *real,* signifying that the work is framed and conducted within the messiness of the real world. Additionally, interaction design researchers should articulate why the outcome of the work is a preferred state, and provide information to help the HCI community understand why this is so.

While many contemporary design research contributions follow a research-through-design approach, they neglect to characterize the outcomes in terms of relevance. Often, the motivation for their work, the detail on the current situation, and information on the preferred state of the world are missing. Without these critical components, a research through design approach appears to be self-indulgent; taking the form of a personal exploration that informs the researcher, but cannot inform the research community and the world at large.

Extensibility

"Extensibility" is defined as the ability to build on the resulting outcomes of the interaction design research. For example, the community may leverage the knowledge created by the resulting artifacts, or the process employed may be used again for a future design problem. Extensibility means that the design research has been described and documented in a way that the community can leverage the knowledge derived from the work.

Conclusion

The landscape of design research is changing, and interaction design research in HCI is undergoing a transformation. In this essay, we have presented our efforts to explore and advance knowledge about research in interaction design as it relates to human-computer interaction. Our work has resulted in a new model of interaction design research within HCI, and a set of four criteria that help evaluate what constitutes good interaction design research.

We hope that our model will provide several benefits to both the HCI and design communities. For the HCI community, the model provides a way for engaging with messy (or wicked) problems that are not easily addressed using traditional science and engineering methods. Hopefully, use of the model will motivate new research by highlighting both technological opportunities and places where gaps in theories of human behavior exist. For the design community, the model articulates how interaction designers can make research contributions through reframing problems and making innovative artifacts.

Our hope is that, through proposing this model, we can add to the growing number of ways to discuss design research, and to continue a much-needed discussion of the role of design thinking and interaction design research in HCI.

De*sign* — Indicating Through Signs

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Introduction

Different disciplines have different concepts of "design," so our understanding of design varies according our particular field. The development of the design concept in the Human-Computer Interaction (HCI) field has inherited approaches, methodologies, and theories coming mainly from Information Systems (IS), Software Engineering (SE), Behavioral and Social Sciences and, more recently, from Design Studies. The rationalist tradition has dominated thinking regarding the design of interactive systems in the Information Systems and Software Engineering fields. As discussed by Ehn and Löwgren,[1] the first approaches to IS development can be characterized by a strong belief in systematic design methods founded in mathematical-logical theories. Research interests in accuracy and technical control guided these approaches. The main assumptions behind them, as suggested in some methods of SE, seem to be that the users (end-user, client, customer, stakeholder, or problem owner) are supposed to give complete and explicit descriptions of their demands in terms of the system to be developed.

Within the rationalist view of IS development, reality is objectively ascertained, is the same for everyone and is composed of entities, their properties, and relationships. Data is understood as a means of representing the truth about reality, and truth is the correct correspondence between some real entities. An information system is a kind of "plumbing" system through which data flow and, within this perspective, the role of the designer is to specify the truth data structure and functions of the system needed by users.[2] According to this view, interface design is just a matter of providing access to the underlying system functionality.

In the 1990s, this picture changed and one of the major sources of inspiration was the theoretical discussion on the actual nature of the phenomenon of designing computer artifacts. A reframing of the rationalistic understanding of computer systems started to consider reality as a social construction based on the behavior of its participating agents. Within this view, the role of the designer is to assist users to articulate their problems; discover their information requirements; and evolve a systemic solution. In other words, "design" is understood by Winograd and Flores,[3] and Adler and

1 Pelle Ehn and Jonas Löwgren, "Design for Quality-in-Use: Human-Computer Interaction Meets Information Systems Development" in *Handbook of Human-Computer Interaction,* Martin G. Helander, Thomas K. Landauer, and Prasad V. Prabhu, eds. (Amsterdam, The Netherlands: Elsevier Science, second completely revised edition 1997), 299–314.

2 Kecheng Liu, *Semiotics in Information Systems Engineering* (Cambridge: Cambridge University Press, 2000).

3 Terry Winograd and Fernando F. Flores, *Understanding Computers and Cognition—A New Foundation for Design* (Reading, MA: Addison Wesley Publishing Company, 1986).

Winograd,[4] as: "... the interaction between understanding and creation." In designing a system, the focus is on concerned involvement rather than on correct descriptions.

In recent years, there also has been a growing interest in the HCI community to think about the development of usable systems as design work.[5] In this work, we will discuss the shift from a rationalistic perspective to the inclusion of interpretative, social, and communicative aspects in designing interactive systems. This position draws upon concepts from Organizational Semiotics (OS) to set up an appropriate foundation for understanding this view of "design" and for it to be reflected in the design of interactive artifacts.

Organizational Semiotics is a discipline that explores the use of signs and their effects on social practices. OS understands that each organized behavior is affected by the communication and interpretation of signs by people, individually or in groups. We base our work on Stamper's school of OS,[6] which proposes a set of methods to deal with information and information systems in a balanced way, taking into account both the technological issues and the human and social aspects of information resources, products, and functions. OS sees informatics from a social angle. We argue that OS provides artifacts that embody knowledge, and support collaboration and reflection among people from the different disciplines involved in interaction design.

This paper facilitates theoretical discussion as well as practical issues on interaction design, proposing a framework in which we have articulated ideas coming from semiotics to conduct work in interactive system design. A brief report on a case study related to the context of Computer-Supported Collaborative Work illustrates our proposal. The paper is organized as follows: we start by conceptualizing design and discussing paradigms that have been the background for interaction design. Then we situate the current understanding of interaction design, as compared to the main approaches of HCI. In the subsequent sections, we present a framework for interaction design inspired by Organizational Semiotics, and illustrate its application in a real design situation. Finally, we discuss the main contributions.

Design: Concept and Paradigms

The word originates from the Latin *designo* meaning to mark out, trace, plan; and also to point out, indicate, signify; to portray; or delineate.[7] In the context of the applied arts, engineering, and architecture; design is both a noun and a verb. Design as a verb is the process of originating and developing a plan for an aesthetic and functional object, which usually requires considerable research, thought, modeling, iterative adjustment, and redesign. The noun is used both for the final plan of action (a drawing, model, or other

4 Paul S. Adler and Terry Winograd, "The Usability Challenge" in *Usability: Turning Technologies into Tools,* Paul S. Adler and Terry A. Winograd, eds. (New York: Oxford University Press, 1992).

5 Phoebe Sengers, Kirsten Boehner, Shay David, and Joseph Jofish Kaye, "Reflective Design," *Proceedings of Critical Computing* (2005): 49–58; Daniel Fallman, "Design-Oriented Human-Computer Interaction," *Proceedings of the Conference on Human Factors in Computing Systems* (2003); and Pelle Ehn and Jonas Löwgren, "Design for Quality-in-Use: Human-Computer Interaction Meets Information Systems Development."

6 Ronald K. Stamper, K. Althaus, and James Backhouse, "MEASUR: Method for Eliciting, Analyzing, and Specifying User Requirements," *Computerized Assistance during the Information Systems Life Cycle,* T. William Olle, Alex A. Verrijn-Stuart, and Love Bhabuta, eds. (Amsterdam, The Netherlands: Elsevier Science, 1988); and Ronald Stamper, "Signs, Information, and Systems" in *Signs of Work Semiotics Information Processing in Organizations,* B. Holmqnist, et al., eds. (New York: Walter de Gruyter, 1996).

7 Latin Dictionary of the University of Notre Dame. Access at: http://archives.nd.edu/latgramm.htm.

description), or the result of following that plan of action (the object produced).[8] Design, ambiguously signifying both process and product, is a term that has been used to include not only the design of physical objects, but the entire range of artifacts made by human beings: from buildings to organizations, behavioral worlds, and theoretical constructs.[9]

Fallman[10] presents an attempt to conceptualize what the discourse of design *is* and what designers *do* when they design. The three accounts for design, which he names the "conservative account," the "romantic account," and the "pragmatic account," are useful to situate our understanding of designing interactive systems, and to frame our approach to *design*.

In the conservative account, "design is thought of as a scientific or engineering endeavor; borrowing methodology and terminology from natural sciences, mathematics, and systems theory, drawing on a philosophical base in rationalism."[11] A widely held model of the design process in the conservative account comes from Simon,[12] and Newell and Simon.[13] Simon has proposed a view of design as a problem-solving process he characterized as a "science of the artificial," distinguishing it from the natural sciences. In his model of designing, he proposes a division of the design process into generation and selection, considering generation either as a random combination of given elements, or as a systematic search of a problem space. This model of designing had profound impact not only on theories specific to the design professions, but on other theories built on the design metaphor, such as those in the fields of psychology, sociology, and economics, and very strongly in computer science.

Within the conservative account, a design methodology movement raised by the works of Alexander[14] and Jones[15] abstracts the design steps into two major processes: an analysis of the problem and a synthesis of a solution. During analysis the ill-defined and unstructured problem, domain is decomposed into more manageable constituents. In the synthesis stage, the designer constructs a solution to the overall design problem by solving each part of the problem constituents found during analysis.

The design of interactive systems, viewed from this account, is supposed to progress gradually from the abstract requirements specification to the resulting artifact: the computer system. The conservative account assumes that there is a problem to be solved, and that the descriptions of this problem can be comprehensively and accurately produced in the form of a requirements specification to be fed into a design process, which culminates with the designed interactive system.

Thus, methodology and structure are the heart of understanding and practicing design, and the designer's role is that of an engineer or a natural scientist.[16] In the conservative account, the designer is seen as a "glass box"[17] in the sense that every step of the process is suggested as rational and possible to describe.

8 www.en.wikipedia.org/wiki/Design

9 Donald Schön, "The Design Process," *Varieties of Thinking*, V. Adrian Howard, ed. (New York: Routledge, 1990).

10 Daniel Fallman, "Design-Oriented Human-Computer Interaction."

11 Ibid., 226.

12 Herbert A. Simon, *The Sciences of Artificial* (Cambridge, MA: MIT Press, 1971).

13 Allen Newell and Herbert A. Simon, *Human Problem Solving* (Englewood Cliffs, NJ: Prentice Hall, 1972).

14 Christopher Alexander, *Notes on the Synthesis of Form* (Cambridge, MA: Harvard University Press, 1964).

15 John Chris Jones, *Design Methods* (New York: Van Nostrand Reinhold, 1970).

16 Daniel Fallman, "Design-Oriented Human-Computer Interaction."

17 John Chris Jones, *Design Methods*.

Schön identifies sources of incompleteness inherent in the conservative model which cannot explain the initial creation of complex design structures; nor can account for the dialectical transformation of structures observed in the ways designers learn through designing. The issue of disagreement is the idea of a design structure: the designer's representation of a problem together with the rule-governed procedures that guide his transformation of it. For Schön, representation and procedures must be compatible. For the model of design as rational decisions, the design structure is assumed to be given with the presented problem. A rational decision process can occur only within such a structure. Hence, the model does not explain how design structures are made and remade in the course of designing. According to Schön, the model coming from the rationalistic tradition is limited either to the special class of artificially constructed problems—where design structure is given from the beginning—or to the later phases of designing—where it takes the form of technical problem-solving within a stabilized structure.

In actual designing, design proposals often are complex, interdependent on each other, and significant in their impact on design structures. This complexity, which Schön calls "figural," is in contrast to the combinatorial or merely additive. Addition or subtraction of one element changes the functional meaning of other elements, with the result that the proposal must be considered different *as a whole.* Examples of figural complexity are found in the drawings of the Gestalt psychologists, computer programs, and human organizations—where a change in one element (position, function, or feature) can produce significant changes in other elements and in the system as a whole. Complexity is closely linked to interdependence.

The "romantic account" of the design process suggests it is not a fully rational and explicable process; it has something "mystical."[18] This account of design can be thought of as "black-boxed"[19] in that the design process is guided by the designer's values and taste, and the product becomes judged according to issues of quality and aesthetics.[20] This view suggests that the arts present better models for design than science.

A design-oriented approach to HCI within this account emphasizes the designer´s individuality, aesthetics, and individual judgment over methodology and control, transparency, and logical reasoning. The product of design and the designer are accentuated, while the process of producing the artifact is opaque.[21]

The "pragmatic account" of design is characterized by its "situatedness": the design process is located in a world populated with people, artifacts, and practices, each with its own history and identity. Rather than science or art, design is understood as a hermeneutic process of interpretation and creation of meaning.[22] Designers iteratively interpret the effects of their designs on the situation at hand. It can be thought of as a reflective conversation with the materials of the design situation. In Schön's perspective:

18 Daniel Fallman, "Design-Oriented Human-Computer Interaction."

19 John Chris Jones, *Design Methods.*

20 Donald Schön, *Educating the Reflective Practitioner* (San Francisco: Jossey-Bass, 1987).

21 Daniel Fallman, "Design-Oriented Human-Computer Interaction."

22 Richard Coyne and S. Adrian, "Is Designing Mysterious? Challenging the Dual Knowledge Thesis," *Design Studies* 12:3 (1991): 124–31.

> Designing is seen as a conversation with the materials of a situation within which new trials are often based on learning from earlier ones. It is seen, for the most part, as a social process in which different designers frame the situation in different ways and learn, when they are successful, to talk across divergent frames.[23]

The pragmatic account focuses on the situatedness of the designer in a real-world situation, and brings to light the combination of roles, practices, and technologies involved in design. [24] The designer has constructive as well as reflective skills.

In the framing of our work, designing is a social process with focus on problem setting as well as on problem solving. It is a dialogue not only with design materials, but mainly among individuals (designers, developers, users, and other stakeholders) in which different views of designing and different ways of framing design situations are contrasted. Design dialogues are dialectical revelations of conflicts among views of design structure held by different parties in the dialogue. Design structures are made and remade during design dialogues. We regard designing mostly within the pragmatic account, as an iterative and interactive process of creating signs, which involves sense production and interpretation by people involved in the design.

Interaction Design and HCI Tradition

Many products that require users to interact with them have not necessarily been designed with the users in mind. Typically, they may have been engineered as systems to perform functions, within the conservative account to design. While they may work effectively from an engineering standpoint, it does not necessarily mean they will be easy, effective, and enjoyable to use from the user's perspective.[25] Because user interfaces are implemented with software, many software engineers believe that the well-established techniques for developing software in general will apply to user interface development. These techniques do apply to user interface software development, but not to designing what that software should implement; namely, the interaction with users.[26] Because of the "human factor," interaction design represents a domain with its own special problems, requiring its own special design techniques. Hartson[27] summarizes this understanding and the interdisciplinary nature of the HCI field as follows:

> Methodology, theory, and practice in the field of human-computer interaction (HCI) all share the goal of producing interactive software that can be used efficiently, effectively, safely, and with satisfaction. ...HCI is cross-disciplinary in its conduct and multidisciplinary in its roots, drawing on—synthesizing and adapting from—several other fields

23 Donald Schön, "The Design Process," 139.

24 Daniel Fallman, "Design-Oriented Human-Computer Interaction."

25 Jennifer J. Preece, J., Yvonne Rogers, and Helen Sharp, *Interaction Design: Beyond Human-Computer Interaction* (New York: John Wiley & Sons, 2002).

26 Deborah Hix and Rex H. Hartson, *Developing User Interfaces: Ensuring Usability through Product and Process* (New York: John Wiley & Sons, 1993).

27 Rex H. Hartson, "Human-Computer Interaction: Interdisciplinary Roots and Trends," *The Journal of Systems and Software* 43 (1998): 103–118.

including human-factors, ergonomics, cognitive psychology, behavioral psychology, systems engineering and computer science.[28]

In line with this HCI view for producing interactive software, Preece, et al.[29] understand design as a practical and creative activity, whose aim is to develop a product that helps its users achieve their goals. Within this understanding, a goal of interaction design is to develop interactive systems that elicit positive responses from users, such as feeling at ease, being comfortable, and enjoying the experience of using them. Within this understanding, Preece et al.[30] conceptualize design by distinguishing two aspects: one conceptual and the other physical. The former is concerned with developing a conceptual model that captures what the product will do and how it will behave; while the latter is concerned with details of the design such as screen and menu structures, icons, and graphics. Design activities begin once a set of requirements has been established and the design emerges iteratively through repeated design-evaluation-redesign cycles involving users. For users to effectively evaluate the design of an interactive product, designers must produce an interactive version of their ideas. In the early stages of development, these interactive versions may be made of paper and cardboard while, as the design progresses and ideas become more detailed, they may be refined pieces of software or material that resembles the final product. The activity concerned with building this interactive version has been called "prototyping."

Therefore, there is a common understanding that developing a product must begin with constructing some understanding of what is required of it; although various approaches to designing may differ in their search for these requirements. User-centered design and participatory design (i.e., involving users) have been advocated as good practices for interaction design in HCI. User involvement in the design process seems to be generally accepted, although varying levels of participation may impact differently on the design product.

We encourage a broader understanding of the design process in which the software is understood as a medium for the creation of virtualities—the world in which a user of the software perceives, acts, and responds to experiences.[31] Moreover, we believe that technology design practices should support both designers and users in ongoing, critical reflection about technology, and its relationship to human life.[32]

As an alternative to the conservative account in HCI approaches, the design of computer applications that are concerned not only with the quality of the final products but primarily with the quality of system usage and the experience it enables, has been one of the main concerns of Scandinavian Participatory Design (PD). PD

28 Rex H. Hartson, "Human-Computer Interaction: Interdisciplinary Roots and Trends": 103.

29 Jennifer J. Preece, et al., *Interaction Design: Beyond Human-Computer.*

30 Ibid.

31 Terry Winograd, *Bringing Design to Software* (New York: Addison Wesley, 1996).

32 Phoebe Sengers, et al., "Reflective Design."

practitioners have long advocated active cooperation between users and designers, and a great amount of research has been conducted in establishing meaningful practices to provide a common ground for discussion among those directly in charge of technology design and use.[33] Participatory techniques are useful instruments to discuss the social context of the users through their active participation. Nevertheless, PD techniques seldom go beyond the early analysis/design activities of development projects.[34]

Taking the Scandinavian tradition as a starting point[35] proposed a more comprehensive development approach called Cooperative Experimental System Development (CESD). This extended cooperative and experimental techniques throughout the entire life cycle of a computer system, including technical design and implementation. Design was seen as the main concern in system development. The focus is on techniques to facilitate designers' and users' involvement in common creative activities. Experimentation with possible outcomes, based on hands-on experience with mock-ups and prototypes, is a central feature of CESD design. Object-oriented tools, as well as techniques to enable a smooth transformation of design artifacts to application code, also are a concern of CESD design.

Prototyping overcomes some of the problems of requirement specification-oriented methods, which usually assume that system design can be based solely on observation and detached reflection. Nevertheless, prototyping methods usually have a narrow focus and tend to limit discussion within the reality created by the prototype. Moreover, there is very little account of how prototypes are related to the current and future work practices of users. We argue that it is equally important that the people involved (designers, developers, users, and other interested parties) share a representation model of the work domain to be supported by the prospective system. Meaning-making is constructed as a result of cooperation between designers, developers, interested parties, and prospective users of the technology being designed. In the context of our design framework, we argue that Organizational Semiotics provides artifacts which serve the participating disciplines as a means for the people involved in the problem design to express and share their knowledge of the world around them.

A Framework for Interaction Design Inspired by Organizational Semiotics

The conservative approaches to interactive software system design present a strict separation between design, implementation, and the use of computational systems. These approaches assume a preexisting common conceptual model of the domain and their agents that is shared by all practitioners. In this way, the problem is reduced to capturing this model and codifying a solution based on the model.

33 Douglas Schüler and Aki Namioka, *Participatory Design: Principles and Practices* (Florence, KY: Taylor and Frances Group, 1993).

34 Kaj Grønbæk, Morten Kyng, and Preben Mogensen, "Toward a Cooperative Experimental System Development Approach" in *Computers and Design in Context,* Morten Kyng and L. Mathiassen, eds. (Cambridge, MA: MIT Press, 1997), 201–238.

35 Grønbæk, et al., "Toward a Cooperative Experimental System Development Approach."

On the other hand, several authors acknowledge the fact that domain models do not in fact exist as an *a priori* object, but instead are socially and dynamically constructed.[36]

In doing design, we rely on various cues, indicators, and conventional signs. Semiotics, the ancient doctrine of signs, leads us to a more precise understanding of information as various properties of signs. Signs are simple entities easy to deal with within the intersubjective domain. Anything standing for another thing or used to signify something else is an example of a sign: words, sentences, traffic lights, diagrams, a wave of hand, or a facial expression. A language community can cross the bridge between signs and reality (what people are observed doing). Within this understanding, system developers and users coevolve, with the language as the mediator of meaning.[37]

In this work, we take semiotics beyond the study of how we use signs for communication to include the shared knowledge and mutual commitment derived from communication in designing. We share with the pragmatic account to design, the understanding that design is about being engaged directly in a specific design situation. This "situatedness" locates the design process in a nested structure in which the informal, the formal, and the technical layers of information and interaction coexist. The "informal layer" represents the informal interactions in a society, the culture in which meanings are established, intentions understood, beliefs formed, and commitments made, altered, and discharged. In the formal layer, forms and rules of an organized society represent meaning and intention (e.g., laws, formal methods of work organizations, models, etc). The inner layer represents the technical interactive system, derived from part of the formal layer which, in turn, draws on the informal layer. Figure 1 is based on the "organizational onion" from OS, and illustrates our proposed account for the design of interactive systems as *indicating through signs*.

A problem setting is part of the design situation understanding and requires articulation in forms that can be appropriated and assessed by people involved in designing (designers, users, developers, and other stakeholders). The design process involves exploring the reality that constitutes the design situation. An ontology is a crucial aspect of what the involved group understands as constituting reality. The ontology charting allows a discussion of meaning and on what the group considers to be important aspects of reality in a particular design situation. System prototyping refer to the group's idea on how to shape their intervention in the situation, based on their ontology and problem articulation. The work in these three layers is performed in parallel, and coevolves: a problem understanding is revealed as the group works on the semantics and solution ideas.

36 Jonas Löwgren and Erik Stolterman, *Thoughtful Interaction Design: A Design Perspective on Information Technology* (Cambridge, MA: MIT Press, 2004); Gerhard Fischer, Stefanie N. Lindstaedt, Jonathan L. Ostwald, Markus Stolze, Tamara Sumner, and Beatrix Zimmermann, "From Domain Modeling to Collaborative Domain Construction," *Proceedings of the Conference on Designing Interactive Systems* (1995): 75–85; and Morten Kyng, "Designing for Cooperation: Cooperating in Design," *Communications of ACM* 12:34 (1991): 65–73.

37 John Rheinfrank and Shelley Evenson, "Design Languages" in *Bringing Design to Software*, Terry Winograd, ed. (New York: Addison Wesley, 1996).

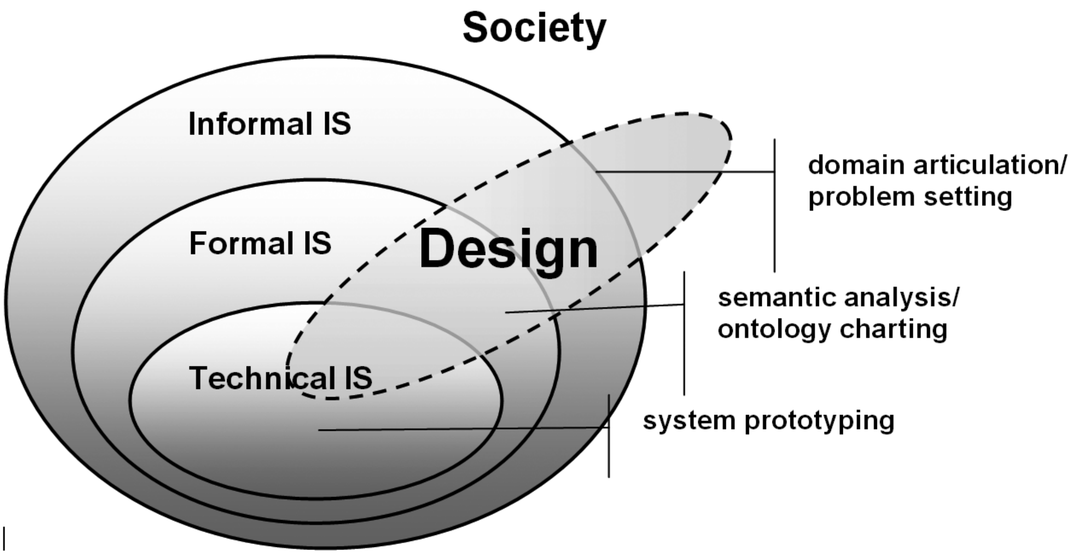


Figure 1
The structure of design as indicated through signs from different layers.

We acknowledge the stages of analysis, synthesis, and evaluation in the design of interactive systems, although not in a linear order. Understanding and describing the problem, finding a solution, and implementing it do not occur straightforwardly as suggested by the conservative account.

Thus, design is conceived as a social process of expressing meaning, communicating intentions, and constructing knowledge, to be carried iteratively and interactively by designers and a group of stakeholders in a participatory style. It is reflective as well as constructive in nature. Several design artifacts, located in the different layers of this structure (from a brainstorming activity or a low-tech artifact situated in the informal layer, to the design models used in the formal layer, to the high-fidelity prototypes) coexist. They aim to encourage and maintain the interaction among users and designers in a social process in which the different views of the design are contrasted and negotiated.

Organizational Semiotics

Organizational semiotics presents theories and methods developed in the course of a research program initiated in the 1960s to allow one to analyze and design information systems in terms of three human information functions: expressing meanings, communicating intentions, and creating knowledge.[38] Studies in OS are not restricted to information expressed in written or graphical discourse, but take into account the semiotic aspects of human interaction in the organization. In the philosophical stance underlying OS, reality is seen as a social construction based on the behavior of agents participating

38 Ronald K. Stamper, "Organizational Semiotics: Informatics without the Computer?" in *Information, Organization and Technology: Studies in Organizational Semiotics,* Kecheng Liu, Rodney J. Clarke, Peter Bogh Andersen, and Ronald K. Stamper, eds. (Norwell, MA: Kluwer Academic Publishers, 2001).

in it: people share a pattern of behavior governed by a system of signs. Since people are constantly communicating and discussing, the world is in constant change.

Semantic analysis is one of the OS methods that focuses on the agents and their pattern of behaviors to describe an organization taken in its broadest sense, including its interactive systems. With the analyst in the role of facilitator, an ontology chart is constructed describing a view of responsible agents in the focal system domain, and their behaviors or action patterns. Some basic concepts of OS adopted in this work are based on Liu[39] and Stamper:[40]

- "The world" is a social construction based on the actions of agents, and on the basis of what is offered by the physical and social worlds: invariant repertoires of behavior constitute the perceivable reality.
- "An agent" is defined as something that has responsible behavior. An agent can be an individual person, a cultural group, a language community, or a society (an employee, a department, an organization, etc).
- "Affordance," the concept originally introduced by Gibson[41] to express the behavior of an organism made available by some combined structure of the organism and its environment, is extended by Stamper[42] to include invariants of the social world: social affordances arise from the norms we share with people around us. Those repertoires of behavior are the ones that make us human rather than animal: "The rich array of affordances available to us we acquire through our engagement in a society able to hand down, through the generations, the useful behavior and perceptions that its members have discovered."[43] Stamper argues that reality, as we know it, was not constructed individually: it was created by cultural development during millenniums. For example, a cup is a human artifact whose use is not only possible because of its physical aspect, but also because of its social affordances (children have learned to use it for drinking, instead of throwing it at someone).
- "An ontological dependency" is formed when an affordance is possible only if certain other affordances are available. An ontological dependency between "A" and "B" means that "A" is only possible when "B" also is possible. The ontological relationship is considered as the most fundamental relationship to model.

The concepts of semantic analysis are represented by means of ontology charts, which have a graphical notation to represent agents (circles), affordances (rectangles), ontological dependencies (lines drawn from left to right), role-names (parentheses), and whole-

39 Kecheng Liu and Alan Dix, "Norm Governed Agents in CSCW," *Proceedings of First International Workshop on Computational Semiotics* (1997).

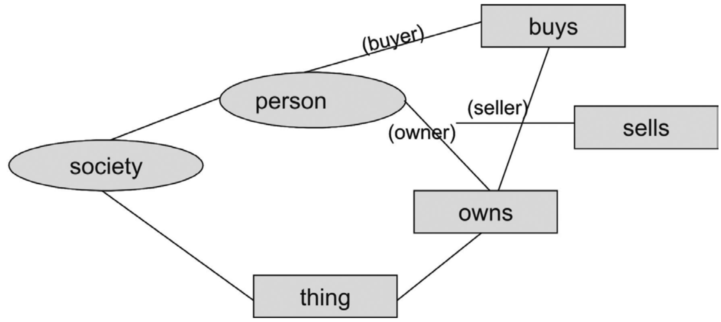
40 Ronald K. Stamper, "Organizational Semiotics: Informatics without the Computer?"

41 James J. Gibson, *The Ecological Approach to Visual Perception* (New York: Houghton Mifflin, 1979).

42 Ronald K. Stamper, "Signs, Information and Systems."

43 Ronald K. Stamper, "Organizational Semiotics: Informatics without the Computer?" 140.

Figure 2
An illustration of an ontology chart.[42]



part relations (dot). The hypothetical example in Figure 2, extracted from Liu,[44] illustrates a fragment of a semantic model represented in an ontology chart. The "society" is the root agent in this model. "Person" and "thing" are both ontologically dependent on "society," which means both and all the other affordances are defined in the context of a certain society. The action's "sells" are ontologically dependent on "owner" (the role of a person who "owns" a "thing"), and the action's "buys" are built upon "person" and "owns." This suggests that, in that particular society, selling is only possible for the person who owns the thing. Selling and buying are referred to the affordance "owns." That means when people are trading, it is the ownership rather than the physical thing itself that is dealt with. In this sense, the representation ontologically reflects the social practice which is dominated by the shared norms in that particular social context.

The meaning of words used in the semantic model is treated as a relationship between the signs and appropriate actions of the agents. We understand the diagram itself as a group of signs. Therefore, the ontology chart is something that is socially constructed in an iterative and interactive process by people involved in designing the organization as well as the interactive system. The design situation is discussed cooperatively in several iterations according to the raised affordances and ontological dependencies: the diagram is not only the object of discussion, but a result of the discussion as well.

In addition to the "semantic analysis," which focuses on the agents' patterns of behavior, "norm analysis" is used to describe the relationships between an intentional use of signs and the resulting behavior of responsible agents in a social context. Considering the example of Figure 2, in a particular society, ownership as well as trading are governed by a set of norms created by the action of agents in that society. At the social level, norms describe beliefs, expectations, commitments, contract, law, and culture, as well as business.[45] Norms can be represented by the use of natural language or "deontic logic"[46] in the late stages of modeling. The norm model

44 Kecheng Liu, *Semiotics in Information Systems Engineering*, 70.
45 Ibid.
46 Kecheng Liu and Alan Dix, "Norm Governed Agents in CSCW."

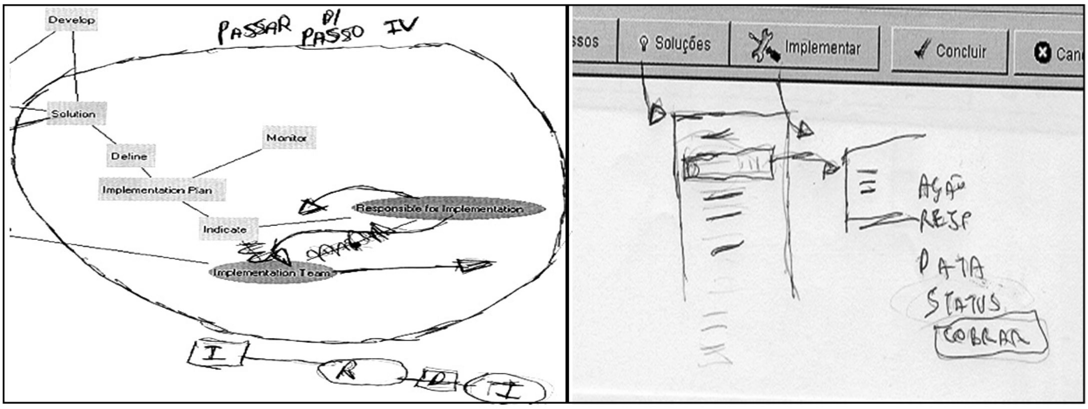


Figure 3
Example of proposed changes during the Pokayoke design.

itself can be understood as a group of signs. In the context of this paper, the norms are modeled as a result of reflection about the organizational context made by the agents in cooperation during the iterations of the design cycle.

Interaction Design in the Proposed Account: Short Report on a Case Study

Pokayoke is a computational system constructed with the aim of exploring the proposed approach to design in practice. The system was designed to support problem solving and decision making in the context of a manufacturing organization that adopts the lean production paradigm. This organization is a unit of a multinational company in Jaguariúna, Brazil which produces automotive parts. Pokayoke is based on one of the factory's procedures to analyze and implement corrective, preventive, security, and health actions, known as "the five steps." The five-step procedure provides a systematic method for dealing with problems in the production routine. Every time an unconformity is identified, an action must be taken to correct it and to prevent its reoccurrence. Also, every time a situation of potential unconformity is indicated, an error-proofing action should be carried out according to the *Poka Yoke*[47] concept of lean production.

The Pokayoke interactive system was developed in fourteen months and distributed in five prototype cycles, with the participation of a diversity of users ranging from shop floor workers to managers. Some participatory techniques (e.g., Starting Conference, Artifact Walkthrough,[48] etc.) were applied in the early iterations, in addition to the Semiotic Conference.[49]

Figure 3 shows a fragment of the combined use of an ontology chart and prototype in discussions during the Pokayoke design. The first versions of the prototype and ontology chart were constructed based on the results of PD techniques in early stages of interaction. The objective of using the ontology chart in this process

47 *Pokayoke* is a hybrid word created by Japanese manufacturing engineer Shigeo Shingo. The word comes from the words *yokeru* (to avoid) and *poka* (inadvertent errors).

48 A summary of an extensive set of PD techniques can be found in Michael J. Müller, J. H. Haslwanter, and John T. Dayton, "Participatory Practices in the Software Lifecycle" in *Handbook of Human-Computer Interaction,* Martin G. Helander, Thomas K. Landauer, and Prasad V. Prabhu, eds. (Amsterdam, The Netherlands: Elsevier Science, second completely revised, 1997), 255–297.

49 Rodrigo Bonacin and M. Cecilia C. Baranauskas, "Semiotic Conference: Work Signs and Participatory Design," *Proceedings on 10th International Conference on Human-Computer Interaction 1* (2003), 38–42.

is not to construct a precise and formal representation of reality. It is used as a tool through which the practitioners can express their understanding and review their work practices while engaged in a signification process. It can be combined with other representation artifacts such as low-fidelity (and high-fidelity) prototypes.

The iterative approach is aligned with the idea that domain models do not exist *a priori.* The semiotic model and the prototypes of the computational artifacts are continuously (re)designed by designers, developers, and practitioners in a process that combines interaction and iteration.

The use of an ontology chart combined with a low-fidelity prototype in Figure 3 shows the need to expand part of the system (represented in the high-fidelity part of the figure). The main focus is not the models or charts themselves, but the discussion about the concepts behind these artifacts. In the Pokayoke case study, although the workers were not able to build semantic diagrams in the first session, they were able to discuss the modeled concepts and rethink their work practices. As discussion takes place, changes and suggestions are reflected in the models and prototypes. A quick example of the discussion that transpired, corresponding to Figure 3, regarding the workplace is illustrated as follows:

- *"The 4th step should be finished only after conclusion or cancellation of the actions."* Some workers used to finish "Step IV" before the conclusion of some actions. A mechanism to avoid that, which is considered a bad practice by the practitioners, was proposed. Figure 3 shows part of the prototype constructed during the meeting. Motivated by discussions about concepts represented in the ontology chart, they proposed to have the *status* for the problem, and the *control* of the due actions (the Portuguese word *cobrar* in Figure 3) represented in the user interface, and;

- *"The person in charge of the five-step procedure is not responsible for the actions of correction."* The "responsible for actions" concept was clarified through the ontology chart. New practices were adopted in the factory regarding this fact, even before the use of the system. As a result, they proposed the inclusion of a field in the prototype interface that identifies the role of the person in charge of the action (Figure 3).

Figure 4 shows part of the new versions of the ontology chart and prototype that resulted from this particular discussion. The diagram represents the relationship between "Brainstorm," "Solution Ideas," and "Actions" discussed during the previous iteration. The new prototype was implemented based on the suggestions, discussions,

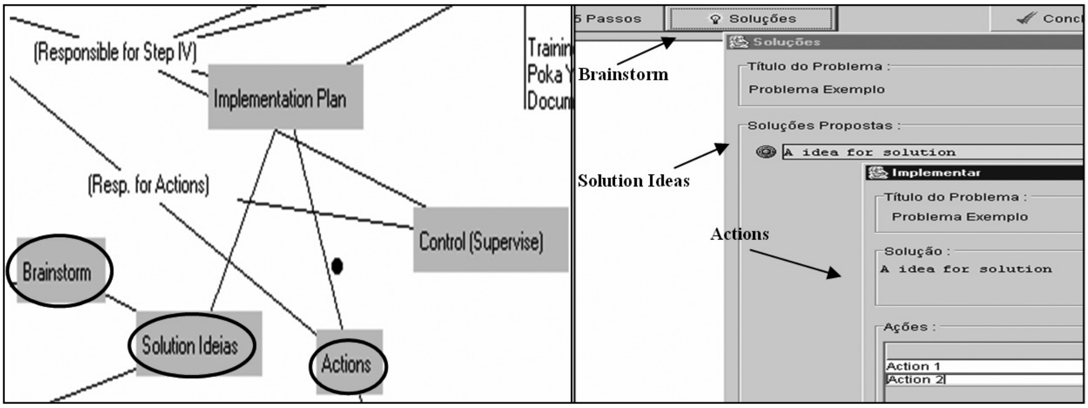


Figure 4
The modified ontology chart and user interface.

and alternatives explored during the previous interaction. The solutions proposed in the "handwrite prototype" were reflected in the new system interface.

After five iterations, Pokayoke substituted the paper-based form of the "five-step" process in the factory. The use of the system in the production line was investigated over the course of one year. The workers' process of making sense of the design elements, both in the abstract level as well as in concrete terms, allied with the feeling of authorship, was fundamental for system acceptance. The workers have expressed these feelings many times during system design and use, saying: "... we have defined this in this way to avoid ...."

The main drawback of the proposed approach encountered during the Pokayoke design was the reading of the ontology chart in the first iterations. This problem was minimized as we focused on the concepts (agents, their patterns of behavior, and ontological dependencies) instead of the notation. After some meetings, the practitioners were able to read the notation and use it to express themselves. The discussion of social norms, for example, resulted in new practices that may have greater value to the organization as a whole than to the computational system itself.

Discussion

> There is no direct path between the designer´s intention and the outcome. As you work a problem, you are continually in the process of developing a path into it, forming new appreciations and understandings as you make new moves.[50]

We share with Schön and Bennett[51] the idea of design having a figural complexity, and demanding a dynamic process of construction, rather than a one-shot approach to it. Moreover, we acknowledge the situatedness character of design, in which the designer is immersed in a world populated with people, artifacts, and practices. Thus, we regard the "designer" not only as the person in charge of

50 Donald Schön and John Bennett, "Reflective Conversation with Materials" in *Bringing Design to Software*, Terry Winograd, ed. (New York: Addison Wesley, 1996), 171.

51 Donald Schön and John Bennett, "Reflective Conversation with Materials."

the process and product of design, but as a group of people (designers, developers, users, and other interested parties) involved in an iterative and interactive process. The design activities are conducted by this group of people in a participatory style.

We share with the Scandinavian design community the understanding that design should be done *with* the users (neither *for* them nor *by* them), and that mutual learning is part of the work of a design group. In the participatory design tradition, prototypes and mock-ups are proposed to allow users to be active in the design process. Nevertheless, prototyping taken in isolation tends to limit discussion within the reality created by the prototype. Our concept of interaction design views it from a social angle, acknowledging from OS the understanding that we construct our social world as layers of affordances that depend on each other for their existence. The semantic analysis enables the group to draw attention to the agents and their pattern of behavior expressing meaning in the ontology charting. In the proposed approach to design, prototypes and ontology charts are artifacts that coevolve, informing each other.

In summary, in the proposed approach, the design process is a social construction of designers, users, and other stakeholders actively engaged in the problem setting as well as in the problem solution. Several artifacts (informal, formal, and technical) are used by the participants during this process as communication and mediation tools in designing the interactive system. The ontology charts provide us with a way to represent the concepts discussed in the design domain. The nodes do not represent concepts in someone's mind but, rather, socially shared, physical, or social affordances (invariant repertoires of behavior). The product of design emerges through several iterations of this process in which analysis, synthesis, and implementation activities are intertwined.

The patterns of agents' behavior in problem setting (social affordances) represented in the ontology chart, reflect the participants' knowledge about the problem domain, exemplifying Schön's: "We could say that our knowing is in our action." [52] During an iteration of the design process, designers and stakeholders are reflecting not only on the phenomena they are representing, and making sense of it through their drawing, but also on their previous understandings of the design problem.

In the context of the proposed approach, conversation does not denote a literal verbal dialog. Rather, it refers to an interactive communication among the participants taking place through changes in the semantic model and prototype drawings, which serve as a representation of shared knowledge. The ontology charts represent their "language of communication" in the sense proposed by Rheinfrank and Evenson,[53] since they have a communicative function as well as the structure of an evolving system of elements and of relationships among those elements.

52 Donald Schön, "The Design Process," 173.

53 John Rheinfrank and Shelley Evenson, "Design Languages."

The ontology chart enables the team to give visible form to the assumptions and the design concepts. At the same time that the language elements are being developed, they are being materialized in the prototype. This simultaneous demonstration of the elements as they are being conceived is crucial because certain concepts may be difficult to imagine without tangible examples. Another purpose for iterative demonstration of the language is to help organizations make development assumptions explicit, and to enable meaning negotiation. In the context of the proposed design framework, meaning is seen not just as the built-in sense of an object, but also as the quality of sense making that objects have and can produce, especially with respect to their social surroundings. The interactive co-construction of the design language is facilitated by the concreteness of the prototypes.

Design as *indicating through signs* allows the participants in designing (designers, users, and stakeholders) to share control of, and responsibility for, the meaning-making process. This requires active participation for co-construction of meaning. This can be accomplished by expressing/communicating signs through the ontology charts and other artifacts, and materializing knowledge in concrete terms through the prototypes.

Conclusion

Methodologies for interactive systems design and development traditionally have drawn upon the conservative paradigm, which considers an objective reality to be discovered, modeled, and represented in the software. If we understand design as communication, and software as a medium for the creation of virtualities, other human communication disciplines can give system engineers a new way to think about interaction design. The designer could be providing the user with tools to create meaning and experience, rather than creating meaning and experience for the user.

Organizational semiotics understands reality as a social construct based on the behavior of its participating agents. OS provides artifacts to represent what we know and share about the world around us. In this paper, we have shown a semiotic-inspired framework that illustrates our understanding of interaction design as communication through signs. This framework has proven its usefulness during the interaction design of Pokayoke, a computer-supported collaborative work system designed for the context of a manufacturer. The approach did not search for an objective truth about the best way to support practice in the factory. Rather, this truth was socially constructed based on meaning negotiations that occurred during the system design. The semiotic models and the use of the prototype screen shots in the design activities have been essential in exploring the connections between the meanings of the design context and the interactions designed to support them in the interactive software system.

Prototyping Social Interaction

Esko Kurvinen, Ilpo Koskinen, and Katja Battarbee

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Introduction

Recent changes in information technology have made social interaction an increasingly important topic for interaction design and technology development. Mobile phones, PDAs, games, and laptops have eased interpersonal communication and brought it into new contexts such as bus stops, trains, cars, and city streets—in fact everywhere people find themselves and move about. In these situations, the old paradigms of one person interacting with technology, or a group at work in an office or collaborating over a shared system, are inadequate for guiding the design of such systems.

For interaction design, these technologies represent new kinds of challenges. Interaction design has inherited its methodic baggage mainly from three sources, none of which specifically focuses on how ordinary people use social technologies. Usability research and human-computer interaction (HCI) seldom quote sociological theory in their premises.[1] While research in computer-supported collaborative work (CSCW) increasingly has focused on questions outside of the workplace, the basis of this field of study still stems from studies of the workplace, in which social organization is devised to support work rather than ordinary activities.[2] New articulations of methods and frameworks are required for designing interactive technologies for social interaction in ordinary activities.

This paper describes a series of studies conducted in Helsinki that focused on prototyping how people interact with each other using mobile multimedia. The central claim is that a prototype is not only a representation of a product or technology—such as a paper prototype, a software prototype, or a physical mock-up—but that it consists of both the representation and the social interaction the participants create together. For convenience, we talk about "prototyping social interaction." The argument of this paper applies in particular to small communication devices meant for everyday life, but it also can be used with other products and services. Social processes inevitably affect the way in which technology is perceived, accepted, and used. If these processes are neglected, designs face risks. In our opinion, there ought to be ways to anticipate at least some of them.

1 Jenny Preece, *Human-Computer Interaction* (Harlow, England: Addison-Wesley, 1994).
2 See Andy Crabtree, *Designing Collaborative Systems: A Practical Guide to Ethnography* (London: Springer, 2003).

Approaches to User Involvement in Prototyping

Buchenau and Fulton Suri[3] define prototypes as "representations of a design made before final artifacts exist." As they note, prototypes range from sketches to different kinds of mock-ups and models.[4] The main aim of prototyping is to produce information for design processes and design decisions, as well as to explore and communicate propositions about the design and its context. From this viewpoint, prototypes serve many purposes. They enable *direct access to challenges and potential solutions.* For example, if the problem is ergonomic, it makes little sense to abstract or theorize about it. In usability testing, prototypes are used mainly to *locate problems in the design and to correct these problems* to make use of the product or service more efficient and enjoyable. Prototypes also are "communicative tools," and sometimes are built explicitly for this purpose. For example, in the car industry it is common to build scale or 1:1 models that preview the proposed vehicle. The aim is to communicate the concept and look of the future product, to obtain feedback, and to prepare the ground for the new product. Finally, prototypes need not address a predefined problem or product. They serve as "aids for imagination." For example, "quick and dirty" experience prototypes can be used when the researchers or developers do not know where to start.[5]

While there is no one way to do prototyping, the role ascribed to the user best distinguishes between possible orientations. In practice, there are several partially incompatible approaches to user involvement. In the "human factors approach," prevalent in usability engineering and cognitive science, the focus is on the individual's behavior and the cognitive and emotional processes as he or she runs through a series of preset tasks in front of a prototype. In contrast, the "participatory design" movement, originating in the Scandinavian tradition of workplace design, involves users intensely throughout the design process.[6] The manipulation of prototype-like representations provides a natural and influential slot for user participation in the process, not simply to generate useful material for design.[7]

One key differentiator is whether the focus is on the behavior of the users and what sorts of claims are made for it. For example, there are purely "artistic" or "inspirational" approaches to user involvement, such as the cultural probes approach,[8] that use imaginative techniques like postcards to collect material from people. The material is used as a backdrop in design sessions, but user studies are not used to test designs or to gain in-depth understanding of people. More typically, *understanding the users' thoughts, dreams, and aspirations* are preferred over mere inspiration. The ultimate interest is not in the observable doings of people, but in their *inner states,* which are regarded as the most important aspect of user-centered design.[9]

The main problem with these approaches is that many products today are designed for interaction, or are used in social interaction, almost out of necessity. This is true not just for communications

3 Marion Buchenau and Jane Fulton Suri, "Experience Prototyping" in *Proceedings of Designing Information Systems DIS'00* (New York: The ACM Press, 2000): 424–433.

4 Simo Säde, *Cardboard Mock-ups and Conversations: Studies in User-Centered Design* (Helsinki: UIAH, 2001); and Carl Adams and David Avison, "Dangers Inherent in the Use of Techniques: Identifying Framing Influences," *Information Technology & People* 16:2 (2003): 203–234.

5 Simo Säde, *Cardboard Mock-ups and Conversations. Studies in User-Centered Design*; Pelle Ehn and Morten Kyng, "Cardboard Computers: Mocking It Up or Hands-On the Future" in *Design at Work: Cooperative Design of Computer Systems* Joan Greenbaum and Morten Kyng, eds. (Hillsdale, NJ: Lawrence Erlbaum, 1991), 169–195; T. Erickson, "Notes on Design Practice: Stories and Prototypes as Catalysts for Communication" in *Scenario-Based Design: Envisioning Work and Technology in System Development,* John Carroll, ed. (New York: John Wiley & Sons, 1995); and Anthony Dunne et al., *The Presence Project* (London: Royal College of Art, 2000).

6 *Design at Work: Cooperative Design of Computer Systems,* Joan Greenbaum and Morten Kyng, eds., 169–195.

7 Konrad R. Budde, Karlheinz Kautz, Karin Kuhlenkamp, and Heinz Züllighoven, *Prototyping: An Approach to Evolutionary System Development* (Berlin: Springer-Verlag, 1992), 24–30; and Kaj Grønbæk, *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach* (Unpublished Ph.D. thesis, Computer Science Department, Aarhus University, 1991). Access at: www.daimi.au.dk/~kgronbak/Thesis/ThesisOverview_ToC.html.

8 Bill Gaver, Tony Dunne, and Elena Pacenti, "Design: Cultural Probes," *Interactions* 6:1 (1999): 21–29.

technology, but also for interiors, and many types of games and cars. However, with the exception of teams in information systems design (ISD) at the workplace,[10] prototyping literature typically uses an individual as the main unit of analysis. As many sociologists have noted, there are inbuilt methodological challenges in understanding social activity by looking at individuals only.[11] The problem is that people are constantly reflecting their action onto how others relate to it. Even if it were possible to anticipate how all individuals would behave in the future, we cannot know up front when the paths of two or more people will meet, and what sort of interaction will occur. Although individual actors have their say in social action, the process or its outcome is not under the control of any one individual.

This paper primarily is intended to show how one can investigate processes of social interaction involving prototypes. Through a detailed case study, we argue that social interaction is worth taking seriously; and we need to study the ways in which it evolves and affects the ways in which people use prototypes. We show that it is important to understand how people interact with others while using a prototype, and how these interactions affect the way in which individuals use the prototype. Our focus throughout is on practices, and what people do, rather than on meanings, and what they say.[12] In Bannon's early terms, we study humans as "actors" rather than as "factors."[13] However, we would like to add that Bannon's call requires attention not just to what individuals do, but also to social interaction, which has received little methodological work outside a small circle of CSCW research.[14]

Prototyping Social Interaction

This paper describes how our work has tried to respond in its own way to Bannon's programmatic call, with lessons learned from CSCW. Our response builds on Buchenau and Fulton Suri's notion of "experience prototyping." Experience prototypes enable design team members, users, and clients to gain firsthand appreciation of existing or future conditions through active engagement with prototypes:

> By the term "Experience Prototype" we mean to emphasize the experiential aspect of whatever representations are needed to successfully [re]live or convey an experience with a product, space or system.... Experience Prototype is any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product, space or system we are designing.... When we use the term "Experience Prototyping" we are talking about methods that allow designers, clients, or users to "experience it themselves" rather than witnessing a demonstration or someone else's experience.... Experience Prototyping is less a set of techniques than it is an attitude,

9 Jane Fulton Suri, "Empathic Design: Informed and Inspired by Other People's Experience" in *Empathic Design,* Ilpo Koskinen, Katja Battarbee, and Tuuli Mattelmäki, eds. (Helsinki: IT Press, 2003), 53. Interestingly, in this context, it has not been asked whether we need to address meanings at all. This discussion has been going on for quite a while within social sciences. For example, David Silverman proposes an alternative for qualitative research approach (i.e., the study of *practices* instead of *meanings*). See David Silverman, "Qualitative Research: Meanings of Practices?" *Information Systems Journal* 8 (1998): 3–20.

10 Konrad R. Budde, Karlheinz Kautz, Karin Kuhlenkamp, and Heinz Züllighoven, *Prototyping: An Approach to Evolutionary System Development* (Berlin: Springer-Verlag, 1992), 24–30; and Kaj Grønbæk, *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach.*

11 Howard S. Becker, "Interaction: Some Ideas" (presented at the Université Pierre Mendes-France, Grenoble). (Accessed June 15, 2005 at: http://home.earthlink.net/~hsbecker/).

12 David Silverman, "Qualitative Research: Meanings of Practices?" *Information Systems Journal* 8 (1998): 3–20.

13 Liam Bannon, "From Human Factors to Human Actors: The Role of Psychology and Human-Computer Interaction Studies in System Design" in *Design at Work: Cooperative Design of Computer Systems,* Joan Greenbaum and Morten Kyng, eds., 169–195.

14 *Technology in Action* Christian Heath and Paul Luff, eds. (Cambridge: Cambridge University Press, 2000); Bonnie A. Nardi, "Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition" in *Context and Consciousness: Activity Theory and Human-Computer Interaction,* Bonnie A. Nardi, ed. (Cambridge, MA: The MIT Press, 1996); and Graham Button and Paul Dourish, "On 'Technomethodology': Foundational Relationships between Ethnomethodology and System Design," *Human Computer Interaction* 13 (1996): 395–432.

allowing the designer to think of the design problem in terms of designing an integrated experience, rather than one or more specific artifacts.[15]

In our opinion, the key point in prototyping social interaction is that "a prototype" is not a piece of technology, constructed to see whether technology works, nor is it something that is "tested" on humans. Instead, the prototype—or a series of prototypes—is a "pair": there is a representation, typically a new piece of interactive technology, *and* several people using it in ordinary social situations. By "social," we do not mean a general sort of label that one could apply to events, but people engaging in interaction with other human participants, either when mediated by the technology or affected by its presence. The representation creates conditions under which people try to understand this technology, redefine it, develop a stance towards it, and change their behavior and opinions of it in dealing with other people. These observations from social interaction, enabled by the representation, are turned into design drivers. They should be given specific and sustained attention, not treated as another set of variables.

In prototyping social interaction, following a few principles in the design process is more important than the qualities of the actual representation used. The following paradigm describes the conditions required for prototyping social interaction.[16] The intention of this setup is to create conditions in which a social organization involving the representation emerges so that this organization can be observed and described in detail. This understanding can be used as a driver in design, and perhaps may even be modeled.

Ordinary social setting. More than one person has to be involved in a unit of study to create the conditions for social interaction in a manner that is appropriate for the design context. Social interaction has to take place in a real context to overcome studio-based contemplation.

Naturalistic research design and methods. People are the authors of their own experiences. They are involved as creative actors, who can and will engage with available products that support them in interests, social interaction, and experiences that they find meaningful. Data from people must be gathered and treated using empirical and up-to-date research methods.

Openness. The prototype should not be thought of as a laboratory experiment. The designer's task is to observe and interpret how people use and explore the technology, not to force them to use it in predefined ways.

15 Buchenau and Fulton Suri, "Experience Prototyping": 424–425.

16 Katja Battarbee, *Co-Experience: Understanding User Experiences in Social Interaction* (Helsinki: University of Art and Design, 2004), 92.

A sufficient time span. The prototype usage ought to be observed for a long enough time, typically for a few weeks at least since it is difficult to get an idea of how people explore and redefine the technology in their actions if the study period is shorter. However, as our third example below shows, one can create prototypes to see how people use the prototype using considerably shorter study periods, provided that the setting is open enough for the participants to freely organize their activities around the prototype.

Special attention to the sequential unfolding of events. One needs to study the stepwise development of the social process, not simply list its outcomes. Interaction unfolds in time, and has to be considered in temporal terms.

In addition, there has to be a conceptual framework for studying social interaction, which is difficult to understand without a proper framework to guide observations and conceptual work. This requirement does not imply that any particular theory is needed. For example, Battarbee's notion of "co-experience" builds on Dewey's pragmatist philosophy and Blumer's version of symbolic interactionism, a sociological tradition consistent with pragmatism,[17] while Koskinen and Kurvinen build on conversation analysis, an offshoot of classic ethnomethodology.[18] In other studies of our topic, mobile multimedia, researchers have utilized activity theory and the sociology of science and technology.[19] The framework ought to be detailed, validated by previous research, and open enough to sensitize designers to social interaction. However, since the aim is to identify and describe how orientations and behaviors towards the prototype are created in social interaction, the framework must be inductive in nature. For these reasons, our work has been based on symbolic interactionism and ethnomethodology rather than more formal theories of interaction—such as the notion of gift-exchange.[20]

Three Studies

From 1999 to 2002, we conducted a series of studies on mobile multimedia. This paper is based on three of these. The first example is from the "Mobile Image" study, which took place in 1999–2001.[21] We gave a Nokia 9110 and a Casio digital camera connected by an infrared link to four groups of five people for approximately two to three months each. The University offered access to a computer system to all participants. Actual messages were collected as e-mail attachments. During the experiment, the male and the female groups sent a total of three hundred and seventy-one e-mail messages, which became our primary data. The service was free of charge.

17 John Dewey, *Art as Experience* (New York: Perigee Books, 1980, originally published in 1934). The notion of experience in Battarbee's analysis depends on Jodi Forlizzi and Shannon Ford, "The Building Blocks of Experience: An Early Framework for Interaction Designers" in *Proceedings of Designing Information Systems DIS 2000* (New York: The ACM Press, 2000), 419–423. For the notion of "co-experience," see Katja Battarbee, *Co-Experience: Understanding User Experiences in Social Interaction*; and Katja Battarbee and Ilpo Koskinen, "Co-Experience: User Experience as Interaction," *CoDesign Journal* 1 (2004): 5–18. For symbolic interactionism and its relationship to pragmatism, see Herbert Blumer, *Symbolic Interactionism: Perspective and Method* (Berkeley: University of California Press, 1986, originally published in 1969); and Hans Joas, *G. H. Mead: A Contemporary Re-Examination of His Thought* (Cambridge, MA: MIT Press, 1997).

18 Harold Garfinkel, *Studies in Ethnomethodology* (Englewood Cliffs, NJ: Prentice-Hall, 1967); Harvey Sacks, *Lectures on Conversations* (Cambridge: Blackwell, 1995); Ilpo Koskinen and Esko Kurvinen, "Messages visuels mobiles: Nouvelle technologie et interaction," *Réseaux: communication, technologie, société* 112–113 (2002): 107–138; Esko Kurvinen, "Emotions in Action: A Case in Mobile Visual Communication" in *Proceedings of the 3rd International Design and Emotion Conference D+E'02*; and Esko Kurvinen, "Only When Miss Universe Snatches Me: Teasing in MMS Messaging" in *Proceeding of Designing Pleasurable Products and Interfaces DPPI'03* (Pittsburgh, PA, 2003).

19 Nancy van House, et al., "The Uses of Personal Networked Digital Imaging: An Empirical Study of Cameraphone Photos and Sharing" in *Proceedings of Computer-Human Interaction CHI 2005*, Portland, OR (New York: The ACM Press, 2005).

The second example is from the "Mobile Multimedia" study,[22] in which we selected three user groups from the Helsinki-based teleoperator Radiolinja's technology and service pilot of their new multimedia messaging service (MMS). The pilot study, which took place during the summer of 2002, lasted about five weeks. Each user was given an MMS cellular phone. Three mixed-gender groups with seven, eleven, and seven members were studied. In all, users sent more than four-thousand messages during the study, with about half of them unique and the rest duplicates in group messages. As in Mobile Image, the service was free of charge.

Our third example, "Mobile Album," is from a concept study done for Nokia Mobile Phones in 2002. In contrast to our interest in mobile multimedia, recent empirical studies of mobile multimedia have repeatedly argued that people show their pictures to other people without ever sending them: cellular phones are largely capture-and-see-devices rather than capture-and-send devices.[23] Mobile Album was specifically constructed to study how people would share experiences with multimedia phones in the presence of others, and how social context shapes the capturing, sharing, and viewing of images. The study also shows how we turned ideas from Mobile Image into a more traditional, low-fidelity prototyping approach. We gave people ten i-Zone Polaroid cameras and a PVC-covered album template. People could cut, paste, and glue their Polaroid stickers on it, and simultaneously see what others did with it. The session took place during a one-day picnic party at *Suomenlinna*, an old fortress island and a popular recreation spot located fifteen minutes from Helsinki. Participants were thirteen students of Finnish language at the University of Helsinki. The second part of this study, called "Indoors," was an indoor party for twenty to thirty guests. Photographing and completing the template took place during a single evening.

Framing Experiences

The first example shows how people may use mobile multimedia for social purposes. In this example, a small and insignificant experience is transformed into something larger than life under suitable conditions by situating it in a story that reframes it. Here, six people first spot a wound, create a murder mystery from it, and organize a simple play, which is recorded with the camera. Eija's wound is "co-experienced" and communicated as a story, not merely an experience.

The title, "Murder at Lammassaari," makes the reader expect a murder mystery. The prologue tells the reader that a scratch on Eija's hand initiated the story. She also explains her blunder: she accidentally deleted the first shot. In the first three images, we see a group of horrified people who witness bloodshed and find a body in

20 Christian Licoppe and Jean-Philippe Heurtin, "Managing One's Availability to Telephone Communication through Mobile Phones: A French Case Study of the Development Dynamics of Mobile Phone Use," *Personal and Ubiquitous Computing* 5 (2001): 99–108; and Sara Berg, et al., "Mobile Phones for the Next Generation: Device Designs for Teenagers" in *Proceedings of CHI 2003*, Ft. Lauderdale, FL (New York: The ACM Press, 2003).

21 Ilpo Koskinen, Esko Kurvinen, and Turo-Kimmo Lehtonen, *Mobile Image* (Helsinki: IT Press, 2002).

22 See Ilpo Koskinen and Esko Kurvinen, "Mobile Multimedia and Users: The Domestication of Mobile Multimedia," *Telektronikk* 101: 3–4 (2005): 60–68; and Katja Battarbee, *Co-Experience: Understanding User Experiences in Social Interaction* (Helsinki: University of Art and Design, 2004), 92.

23 Tim Kindberg, et al., "How and Why People Use Camera Phones" (Consumer Applications and Systems Laboratory, H&P Laboratories, Bristol, England, HPL-2004-216, November 26, 2004). Available at: www.hpl.hp.com/techreports/2004/HPL-2004-216.html (Accessed August 15, 2004); and*Empathic Design*, Ilpo Koskinen, et al., eds., Chapter 7; Marc Davis, et al., "MMM2: Mobile Media Metadata for Media Sharing" in *Proceedings of Computer-Human Interaction CHI 2005*, Portland, OR (New York: The ACM Press, 2005); and Nancy van House, et al., "The Uses of Personal Networked Digital Imaging: An Empirical Study of Cameraphone Photos and Sharing."

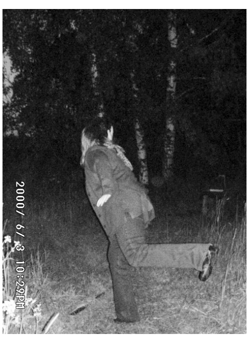
the grass. The next three pictures show a runaway murderer, who is caught and punished. The movie-like atmosphere is emphasized in the final image, which underlines the fictional, movie-like character of the episode by referring to the Oscar gala, which situates the story in the safe world of mainstream movies.

A

B

C

D



Example 1. ***Murder at Lammassaari***
The long awaited horror movie shots!

> Unfortunately, I messed up and deleted the first image by accident (but I've heard I'm not the only klutz among us...). The first image was a picture of the murderer's hand (the story started with a small scratch on Eija's hand sometime in the darkest hours of the night at the Lammassaari summer party.
> Liisa

A Horror at Lammassaari: A murder has been committed!

B A body in the grass (note the smile).

C The body is found.

D The murderer runs for it.

This example shows how new technology may enable social interaction in many ways simultaneously. An actual experience in Lammassaari becomes reportable, tellable, and shareable because of technology at both the sending and receiving ends. Activities at parties may of course evolve into plays, but a camera and a phone makes this process different. When there is a camera, the play is specifically staged for it. These people are not experiencing just a play, but a play played for the camera with an eye to sharing it later. Finally, there was an advertisement at the beginning of the message. That it exists at all shows that this story had been discussed for quite some time earlier: the information exchange had begun prior to the actual story being shared.

Mobile Image made it possible for us to study ways in which people use a camera and a mobile phone to capture and reconstruct experiences, and share them with other people. Among the methods we have explored have been postcards, riddles, teases, questions and answers, as well as stories.[24] In this context, Ling and Julsrud talk about "genres," which we see as a special case of social interaction. Genres—like Hollywood-style murder mysteries—provide conventional means for giving shape to constructing messages.[25] As *Murder in Lammassaari* shows, genres provide important resources for observing, imagining, and reporting social activities.

24 Ilpo Koskinen, Esko Kurvinen, and Turo-Kimmo Lehtonen, *Mobile Image* (Helsinki: IT Press, 2002).

25 See Rich Ling and Tom Julsrud, "The Development of Grounded Genres in Multimedia Messaging Systems (MMS) among Mobile Professionals" in *A Sense of Place*, Kristóf Nyíri, ed. (Vienna: Passagen-Verlag, 2005).

E

F

G

Routines and Creativity

While in Mobile Image sending a multimedia message to another phone could take several minutes, in Mobile Multimedia, the process was considerably faster. As expected, this was reflected in how people used their devices to capture and share experiences with their peers, and the forms of social interaction became more elaborate. People were able to not just capture and send experiences, but also could respond to messages almost in real time.

Examples of messages that make a response possible, but do not require one, are reports of good news, insults, "good night" messages, "wish you were here" messages, and many others.[26] Sometimes a missing reply is noticeable and may prompt sanctions. If one asks a question, one can expect a quick answer. In Mobile Multimedia, these "sequences" include question-answer pairs, greetings, teases, and riddles.[27] These are orderly acts that people use in ordinary life to make sense, and to reinterpret their experiences using a piece of communication technology. They also explain a good deal of variation in use over time.[28]

E Plot climax: The murderer is caught.

F The murderer gets what he deserves
—The Happy Ending.

G The photographer wins an Oscar, responding to acclaim like a champion.

Example 2. ***Good morning greeting***

In Example 2, Hanna sent early morning greetings to her spouse. It was one of many greetings sent during the study. As such, it is a good example of an age-old practice familiar to anyone from numerous ordinary situations in everyday life.[29] Greeting such as this typically were routinely acknowledged, if replied to at all. These are examples of "routinized" communication patterns and ways of communicating things and, as such, fit the notion of genres. However, a closer look reveals that people do not merely take this material and shove it in a ready-made set of response types, series, or sequences. For example, greetings enable creative spin-offs. Later that afternoon, Tuomas recycles Hanna's tired-looking photo, sending a mock personals ad to everyone in the group.

26 Battarbee, *Co-Experience: Understanding User Experiences in Social Interaction.*

27 See Koskinen, et al., *Mobile Image*; Kurvinen, "Only When Miss Universe Snatches Me: Teasing in MMS Messaging"; and Koskinen and Kurvinen, "Mobile Multimedia and Users: The Domestication of Mobile Multimedia."

28 Ilpo Koskinen, "User-Generated Content in Mobile Multimedia: Empirical Evidence from User Studies" in *Proceedings of International Conference of Multimedia and Expo ICME'03,* Baltimore, MD, (IEEE Publication, 2003).

29 Alex S. Taylor and Richard Harper, "Age-Old Practices in the 'New World': A Study of Gift-Giving between Teenage Mobile Phone Users" in *Proceedings of Computer-Human Interaction CHI'02*, Minneapolis, MN (New York: The ACM Press, 2002), 439–446.

Example 2 (continued)

From Hanna to Tuomas:
"Morning!"

A

From Tuomas to all:
A "I am 20, a hot sassy panther lady from the city! You hunk of male, catch me if you dare!—Always on the prow!"

Tuomas used this reply to step outside routine communication patterns, and thus opened himself to an affectionate and quick counter attack. Hanna replied with two messages. The first, jocular message consists of a similar ad on behalf of Tuomas, with a primitive wooden sculpture representing him. The second message offers the contents of a diaper to Tuomas, thus displaying her disapproval of the earlier message in a strikingly literal way. She did not have to use a bad word with this picture. After the first message, there was a natural slot for Tuomas to take his turn, but the second reply cuts in and efficiently kills the line of conversation.

B

From Hanna to Tuomas:
B "I am Tuomas of the Jungle, 37, humbly known as the king of the forest. Seeking a wild 60 yr-old jungle woman to come and grab me off the vines.—Dangling yo-yo."

\- From Hanna to Tuomas
C And just for daddy.

C

The morning greeting above could have initiated a routine exchange of greetings. However, people do not always behave as expected. People may be humorous, witty and, at times, even nasty to each other. Even routine interactions can, and are, exploited in innumerable ways—not in line with the pattern, but to make a point here-and-now. Human activity often is creative, which makes it difficult, if not impossible, to model. Any system designed to support communication has to provide room for these outbursts of creativity.

Sharing Photographic Experiences as They Happen

Our third example, from Mobile Album, shows how categories emerged in action rather than explicit negotiations. Mobile Image already taught us that the notion of "category" does not properly support action through mobile multimedia. However, since Mobile Image was based on collecting actual messages, it did not provide us with access to what people actually do when they get multimedia messages and decide to respond to them. It was this work that we probed in Mobile Album.

To take an example, one group of images that emerged in Suomenlinna consisted of round shapes. The first images in the series were inspired by one accidental shot in which one participant was eating and her mouth was wide open. Others soon picked up the cue. A few minutes later, there were many similar pictures as some participants started to take pictures of each other's mouths. At this stage, the newly created collection of round shapes was labeled "mouths," after which more pictures of similar or closely related shapes were added, including openings of tunnels and beer cans shot from above.

This example shows that the process of creating the metaphor of "mouths" from the originally descriptive term was stepwise and collaborative. Several people participated in creating the category, which became a source of fun as the mouth metaphor became increasingly more complicated. This example also shows that the abstraction process was social, since several people participated in creating the category, which became a source of fun as the "round shapes" category became increasingly rich in content.

Indoors, the second study of Mobile Album was from a cocktail party situation. We wanted to study how people create meaning in the situation using our experience prototype in the absence of the clear-cut visual structure of Suomenlinna, where the scenic fortress island itself and the easily identifiable physical activities within provided a natural conceptual structure for the event. In contrast, as the main activities in Indoors were socializing, eating, and drinking, there were fewer visual elements and less action to capture on film. Consequently, people started to crop and cut shapes out of photos, and create panoramas and collages not only out of photos, but also using physical objects such as candies that were glued on the paper prototype. Instead of creating collections of similar objects—as at Suomenlinna—the activity was geared towards editing and manipulating the otherwise monotonous visual scenery. However, although the methods of creating meaning were different, the process was just as social. For example, when we traced the process later from the videotapes, all collages in the template were created collaboratively, the idea of cropping and cutting images with scissors having been similarly picked up from earlier creations by others.[30]

In Mobile Album, our design conclusion was to suggest that any system for storing albums would have to offer the opportunity to keep categories plastic, renameable, and open so that people could create and edit categories at will. In contrast, systems relying on ready-made categorization schemes or automated classification systems do not support the discovery and fun inherent in collaborative album-building. Furthermore, we argued that the need for image editing or assisted storytelling abilities do not exist in the abstract, but are tied to the nature of the activity; some events are reportable

30 Esko Kurvinen and Ilpo Koskinen, "Mobile Photo Album: An Experience Prototype" in *Empathic Design,* Ilpo Koskinen, Katja Battarbee, and Tuuli Mattelmäki, eds. (Helsinki: IT Press, 2003): 96–100.

as is, while others cry for assistance of some kind. Our analyses were translated into scenarios of how people classify images into groups; how they turn these classifications into fun, and how classifications, once created, direct social interaction in the future.

Discussion

Interaction design has created a knowledge base from a variety of disciplines. Primarily, the field has turned to usability research, cognitive psychology and, to some extent, CSCW in the search for concepts and theories. Through these choices, the field tends to have an individualistic tendency. With few exceptions, social action is studied at the workplace rather than in mundane contexts. However, when interaction design has matured, it increasingly has had to address technologies that people use to do things with other people in settings not constrained by the tasks and rules of the workplace.

This paper has described how one can use prototypes in studying social interaction with and through technology. One example has come from a study of one particular technology: mobile multimedia. We have demonstrated that it is possible to study how prototypes function in social interaction. In the three studies reported, we observed how groups of friends and acquaintances invented ways of using mobile multimedia technologies. We have gathered log data, actual messages, interviews, and videotapes to make sense of how people invent uses for these representations while interacting with other people. The representations have been at a variety of technology levels, from paper-and-scissors to prelaunch products and services.

Our approach to prototyping social interaction was inspired by Buchenau and Fulton Suri's notion of experience prototyping,[31] but our interest is the emergence of social activities rather than how experiences take shape in these activities. Our primary goal was not to create a shared experience that could later be used as a reference point in design work, but to create a setup in which we could analyze in detail how people construct messages; for example, how messages form sequences and how category systems evolve. We have not simply gained insight and inspiration or tested our ideas based on what we have witnessed in our studies, but also described and modeled several social practices for the purposes of product development. Thus, our contribution relates not so much to prototypes *per se*, or their role in providing for user-designer interaction, but to the ways of looking at the data prototypes generate when exposed to social action. Although this work was partly based on ethnomethodology and conversation analysis, insights from these studies also have led to a new understanding of user experience as co-experience—as something people create together.[32] Another difference is that, in our opinion, prototyping social interaction requires an even

31 Buchenau and Fulton Suri, "Experience Prototyping."

32 Katja Battarbee, *Co-Experience: Understanding User Experiences in Social Interaction.*

more open approach to prototyping than experience prototyping. If people are given the time and opportunity to explore technology, they will develop uses for it with others.[33] The main similarity is that the prototype does not have to be technologically advanced, detailed in design terms, or expensive.

There are several reasons for prototyping social interaction. Many technologies—for example, mobile multimedia—are inherently social. There is a place for ergonomic and usability studies, but to fully understand the design potential of technology we need to understand what interpersonal activities it might support. Still, many if not most ways of describing social action use social activities as resources rather than study them in detail.[34] In contrast, we treated our prototypes only as bases for social interaction, which became the *topic of analysis.* These studies were not aimed at producing product ideas, but to make sure that such ideas are based on a solid understanding of the intricacies of social interaction and what happens when the prototype is embedded in social action. It is then up to project constraints, design teams, and the maturity of organizations to turn this understanding into product ideas. Our approach is more in the tradition of ethnographic research, primarily aiming at better understanding of human behavior in this technological context. It should be judged in terms of its ability to generate theory that helps the design field more generally—not simply in terms of its ability to serve the contemporary needs of developers.[35]

Our study has dealt with mobile communications technology. Mobile multimedia have provided us with a perspicuous setting that makes social phenomena observable and reportable in sufficient detail. A similar approach has been used in a variety of other settings such as exploring how audio files can augment photography.[36] This raises the question about whether the prototyping social approach can be applied to "slow technologies" such as intelligent furniture or textiles.[37] Another open question is the place of prototyping social interaction in the design process. The answer to both questions depends on the presumption that our point is conceptual—aimed at advancing a shift in thinking rather than suggesting something totally new for the most advanced design practice. The approach advocated in this paper can easily be adapted to researching, say, interaction with robots or intelligent textiles. If for practical reasons one can do only one prototype, then it is wise to conduct research early on in the design process, when design drivers still are open. However, as our examples have shown, research can be conducted at considerably later stages of the design process just as well. In the final analysis, the purpose of prototyping social interaction is not so much about saying what the future product or system should be like. Rather, it is about providing a more accurate description and understanding of the social phenomena related to the product or service idea.

33 As argued by, for example, Mika Pantzar, *Kuinka teknologia kesytetään?* (Helsinki: Tammi, 1996). [*How Is Technology Domesticated?* in Finnish]

34 Don H. Zimmerman and Melvin Pollner, "The Everyday World as a Phenomenon" in *Understanding Everyday Life: Towards the Reconstruction of Sociological Knowledge,* Jack D. Douglas, ed. (New York: Routledge & Kegan Paul, 1973), 80–104.

35 Paul Dourish, "Implications for Design" in *Proceedings of Computer-Human Interaction CHI 2006,* April 22–27, Montréal, Québec, Canada (The ACM Press, 2006), 541–550.

36 David Frohlich, *Audiophotography: Bringing Photos to Life with Sounds* (London: Kluwer, 2004).

37 Lars Hallnäs and Johan Redström, "Slow Technology: Designing for Reflection," *Personal and Ubiquitous Computing* 5 (2001): 201–212.

Emergent Interaction: Creating Spaces for Play

Ben Matthews, Marcelle Stienstra, and Tom Djajadiningrat

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Introduction

Designers of technology always have designed for interaction. Everything in the built environment is made to be used in some way, by some people, for some purposes, irrespective of how peripheral any notion of "interaction" may have been during the design process. If the practice of interaction design deals with matters such as the determination of what interactive devices should be built, how functionality can be accessed, and how products can facilitate interaction, then among the questions that face interaction design "research" are methodological concerns such as how we should seek to understand what is built and how it is used—the implementation of technology and its appropriation. We will address these latter issues in this paper.

"Interaction design" is a relatively recent term. In one sense, it is a document of the recognition of the importance of understanding the development and consumption of technology as being irredeemably situated in human, social, and organizational contexts. Yet it also is an acknowledgement of the central role of the designer in shaping human interaction with technology. As a disciplinary label, interaction design is a purposeful delineation from the more analytic discipline of human-computer interaction (HCI), a field to which it owes a historical and practical debt.

This shift from HCI to the focus on the *design* of interactive systems carries with it familiar (to this audience) difficulties for the conduct of research. Only a few years ago, design research was characterized as an activity in search of a definition[1] in reference to the methodological pluralism and breadth of focus of research conducted within the field. Just how one should design, study design, conduct studies to inform design, and generate "design knowledge" continue to remain open questions for design research, with many competing perspectives being offered.[2] These issues in design research are a more attenuated predicament for *interaction* design research, particularly when one considers the breadth of settings in which interactive devices are now used, and the topics of interest to interaction design.

1 Susan Roth, "The State of Design Research," *Design Issues* 15:2 (1999).

2 Typically, design research has been informed by research practice drawn from other disciplines (e.g., psychology, physical and social sciences) with long, pedigreed and contrasting traditions of inquiry. There also have been moves away from established research models towards recasting design practice as a form of research itself, but this remains contested ground. See, for instance, *Design [x] Research: Essays on Interaction Design as Knowledge Construction,* Pelle Ehn and Jonas Löwgren, eds. (Malmö, Sweden: School of Arts and Communication, Malmö University, 2004); Bryan Lawson, "The Subject that Won't Go Away, but Perhaps We Are Ahead of the Game: Design as Research," *Architectural Research Quarterly* 6 (2002); and Darren Newbury, "Knowledge and Research in Art and Design," *Design Studies* 17 (1996).

Diverging Technologies, Settings, and Practices

First, one may consider the consequences for research of the increasing diversification of technology, and the (parallel) breadth of settings in which it now is used. The office, formerly the archetypal setting for the consideration of human-computer interaction, is losing ground in light of the realization that dichotomies such as work/play, domestic/commercial, amateur/professional continue to be blurred through the emerging patterns of use of distributed, mobile, and ubiquitous technologies. Where once sharp lines may have been drawn between, say, work and leisure; increasingly we see only shades of grey. And this is true whether we are speaking of work times, work places, or work tools. Thus, office environments are less likely to provide designers with a realistic gamut of where and how work technologies will be used and appropriated in use. This predicament constitutes a methodological issue when new technology is designed not simply to support existing practices (as traditionally has been the strength of research in computer-supported cooperative work (CSCW)), but to introduce wholly new practices,[3] suggesting that even basic methodological matters for research such as what to topicalize, what to look for, and where to find it are not necessarily straightforward for interaction design.

The Conceptualization of Interaction Design Topics

The diverging settings of use, general diversification of technology, and introduction of novel practices are factors that have encouraged interaction design researchers to focus on issues broader than those inherited from HCI, and to question existing conceptualizations of topics. Interaction design research already demonstrates distinctive disciplinary foci. Notions such as aesthetics of narrative,[4] expressiveness,[5] aesthetics of interaction,[6] aesthetics of actions,[7] experience design,[8] affective computing,[9] and embodiment[10] exhibit, in different ways, an orientation to the complexity of the networks of people, activities, and contexts brought into relationship by technologies. This too becomes a methodological difficulty due to the nature of these concerns.

For example, consider the increasing interest in the user's "experience" as the object of design[11] "Experience" (like other grails of design research such as "aesthetics") is a term that is not easily amenable to being operationalized in research. It is better understood as a "family resemblance"[12] concept in that it can be intelligibly used in a range of subtle, but important, different ways. Such terms take their definitive sense from their use in a local context. Thus, operationalizing such a concept for the purposes of research can get us no closer to "what it is," since stipulating an operational definition denies the flexibility that the term ordinarily enjoys in vernacular use. There is no core platonic essence of "experience": the term is a polymorph. Research that attempts to operationalize notions such as "experience" may, in some cases, tell us something of interest

3 See Andy Crabtree, "Design in the Absence of Practice: Breaching Experiments" (paper presented at *DIS2004*, Cambridge, MA, 2004); where valuable attention was paid to this issue.

4 Anthony Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (London and Basel: August/Birkhauser, 2001).

5 Tom Djajadiningrat et al., "Tangible Products: Redressing the Balance between Appearance and Action," *Personal and Ubiquitous Computing* 8:5 (2004).

6 Lars Hallnas and Johan Redstrom, "From Use to Presence: On the Expressions and Aesthetics of Everyday Computational Things," *ACM Transactions on Computer-Human Interaction (TOCHI)* 9:2 (2002).

7 Mads Vedel Jensen, Jacob Buur, and Tom Djajadiningrat, "Designing the User Actions in Tangible Interaction" (paper presented at *Critical Computing: Between Sense and Sensibility*, Aarhus, Denmark, 2005).

8 Nathan Shedroff, *Experience Design 1* (New Riders Press, 2002).

9 Rosalind W. Picard, *Affective Computing* (Cambridge: MIT Press, 1997).

10 Paul Dourish, *Where the Action Is: The Foundations of Embodied Interaction* (Cambridge, MA: MIT Press, 2001); and Toni Robertson, "The Public Availability of Actions and Artefacts," *Computer Supported Cooperative Work* 11 (2002).

11 Johan Redström, "Towards User Design? On the Shift from Object to User as the Subject of Design," *Design Studies* 27:2 (2006).

12 Ludwig Wittgenstein, *Philosophical Investigations* (Second Edition), G. E. M. Anscombe, ed. (Oxford: Blackwell, 1958).

about the particular sense stipulated in its operationalization; and may be useful as benchmark-type means of comparison across cases (although exactly *what* is being compared is still an issue). However, the results of such research cannot be mapped back onto the range of phenomena or uses ordinarily associated with the term (be it "experience," "emotion," "aesthetics," etc.), since their ordinary use is not so constrained.[13] The point is that *a priori* definitions (theoretically informed or otherwise) do not help us investigate context-bound issues such as "user experience" or "interaction aesthetics." For similar reasons, laboratory experiments, questionnaires, and other analytically-specified frameworks for investigation often fall afoul of these same methodological troubles. These notions must be investigated in context, and in use, if we are to attempt to illuminate their ordinary and actual nature.

Furthermore, interests in such notions as "experience" have encouraged researchers to problematize extant conceptualizations of topics, and seek theoretical insight from fields beyond design research and HCI.[14] One such conceptualization that serves as an apt case in point is Norman's[15] influential discussion of good/usable design in terms of the fit between the designer's "conceptual model" of the behavior of a product, and the user's "mental model." Norman suggests that to the extent there is a "meeting of minds" between the designer and user *through* the product's behavior, the design can be seen as successful. This particular conceptualization continues to be of great importance to the field and practice of interaction design. But we should note that it is not merely an idle characterization. On the contrary, it encourages an understanding of successful design as contingent upon accurate predictions of users' interpretations and behavior. It defines *as problematic* deviations from "intended use," and it characterizes the artifact's purpose in a (largely) instrumental and semiotic manner. It could be argued that such a conception has informed even the label "interaction design" insofar that it is understood as the design of interaction.

It is here that we see the potential to cross-fertilize interaction design research with theoretical perspectives adopted from other disciplines. In this paper, we want to problematize the notion that interaction design is the design of interaction. We argue that it is not interaction per se that designers of products and systems design, but that the relationship between design and interaction-in-use is complex. We illustrate this through an empirical analysis (based on naturally-occurring, in situ, video data) of the use of two interactive devices for children, demonstrating how emergent forms of interaction arise in use. The product domain these cases are drawn from (i.e., game/toy design) is fitting for a consideration of aspects of interaction such as engagement, appropriation, interaction modalities, and interaction aesthetics.[16] The cases explore the benefit of moving away from conceiving of "good" design primarily in terms of fitness for purpose, efficiency, clarity, and effectiveness. We intend

13 See also Jeff Coulter, "Remarks on the Conceptualization of Social Structure," *Philosophy of the Social Sciences* 12 (1982).

14 An important example is Anthony Dunne, *Hertzian Tales: Electronic Products, Aesthetic Experience and Critical Design* (London: RCA: CRD Research Publications, 1999).

15 Donald A. Norman, *The Design of Everyday Things* (New York: Doubleday, 1st Doubleday/Currency ed.,1990); and Donald A. Norman, "Cognitive Engineering" in *User- Centered System Design: New Perspectives on Human-Computer Interaction*, Donald A. Norman and S. W. Draper, eds. (Hillsdale, NJ: Erlbaum Associates, 1986).

16 We expect that the lessons we draw from this analysis are generally applicable to interaction design to the extent that goals such as engagement, appropriation, and interaction aesthetics also are design objectives in other domains.

our discussion to contribute to the budding dialogue between the fields of design research and science and technology studies,[17] drawing on Akrich's[18] notions of "scripts" and "de-scription." These enable us to rethink inherited conceptualizations, such as the role of the designer, and to clearly articulate emergent forms of interaction in use. Our analysis of children's play around these toys shows just how meaning emerges locally from interaction, recommending that understandings of interaction need be inherently tied to an in situ examination of sites of use, and that these understandings may well defy abstraction from those sites.

Scripts, Social Constructivism, and Technological Determinism

The nature and scale of the designer's role in shaping the material world is a contested one. A number of discussions in science and technology studies[19] contrast technological determinism with social constructivism. In determinist views, technology itself is credited with a pervasive responsibility for shaping users' worlds—the nature of the technology released into the world determines much of that world: what is used, who can use it, and how it is to be used. In this view, users are channeled into acting in certain ways by the tools they are conscripted to interact with. In contrast, constructivism grants social actors the agency to willingly create their worlds—people are responsible for generating and sustaining the meanings that technology has, and the uses to which it can be put. Here, what technology "is" does not determine, but is itself determined by, social praxis.

However, for scholars such as Akrich, neither of these accounts is sufficient. Instead, she charts a middle ground, introducing the dual notions of "scripts" and "de-scription" to attempt to account for the active role that both designers and users have in negotiating the technology's consequent meaning and use. Her point is that designed objects are inscribed with (designers') assumptions about the world in which the product will be used, who will use it, etc.[20] This provides a "script" for a play between user and product which dictates certain roles to be enacted in use. At the same time, there is no guarantee that users will play these particular roles. Indeed, users are quite free, in many circumstances, to define their own parts.[21] Therefore, on the one hand, the object redefines the user's world by virtue of what it is; while, on the other hand, the object itself is redefined through being "dis-placed" into a setting that was not completely or accurately envisaged for it, and one in which it is never only used according to plan. For Akrich, this is the play of "de-scription"—that technology, use, actors, and settings are mutually constitutive of one another.

Obviously, this discussion is relevant for interaction design, both for grasping the nature of the role and responsibility that the designer has in shaping the material world,[22] and for attempting to understand the complex relationships that emerge in use between

17 For example, Edward Woodhouse and Jason W. Patton, "Design by Society: Science and Technology Studies and the Social Shaping of Design," *Design Issues* 20:3 (2004).

18 Madeleine Akrich, "The De-scription of Technological Objects" in *Shaping Technology /Building Society,* Weibe E. Bijker and John Law, eds. (Cambridge, MA: MIT Press, 1992).

19 For example, Donald A. MacKenzie and Judy Wajcman, *The Social Shaping of Technology: How the Refrigerator Got Its Hum* (Milton Keynes: Open University Press, 1985); and Nelly Oudshoorn and Trevor Pinch, *How Users Matter: The Co-construction of Users and Technology* (Cambridge, MA: MIT Press, 2003).

20 Compare Lucy A. Suchman, "Office Procedure as Practical Action: Models of Work and System Design," *ACM Transactions on Information Systems* 1:4 (1983).

21 Madeleine Akrich, "The De-scription of Technological Objects": 208.

22 Peter-Paul Verbeek, "Materializing Morality: Design Ethics and Technological Mediation," *Science, Technology, and Human Values* 31:3 (2006).

people and products. When determining how we can better understand the ways in which technologies are appropriated in use, we are committed to exploring not only products-in-themselves, but their active role in constituting and being constituted by users in interaction. Furthermore, in this domain, the contrast between the concepts of "games" and "play" is analogous to that between determinism and constructivism.

Games and Play

It is difficult to conceive of games without rules: games, in order to be games, must be played in a certain way. They have a structure. Games definitively contain a (usually explicit) script in Akrich's sense. While many games permit multiple ways of playing, there always must be a wrong way to play—a "game" is not a game if there cannot be a spoilsport. Game designers create a structure (through the rules of the game) in which players can participate, but designers are unable to design the players' experience,[23] which cannot be completely determined in advance. It must be enacted. The experience is made possible through, but not dictated by, the rules of the game. This point is complicated when we, following Akrich and Latour, begin to consider the "tools of play" as participants in this scene—devices for gaming (e.g., joysticks or gamepads) also carry scripts which operate in parallel with those of the game.

On the other hand, play may or may not be game-like. While it is certainly true that we play games, the notion of "play" is much broader than "game." Gadamer indexed the range of uses of the word in his discussion of the nature of "play":

> [W]e find talk of the play of light, the play of the waves, the play of a component in a bearing-case, the inter-play of limbs, the play of forces, the play of gnats, even a play on words. In each case, what is intended is the to-and-fro movement which is not tied to any goal which would bring it to an end.[24]

Clearly, there is play both within and outside of games. And as Gadamer notes, play also can be the *suspension* of goal-directed activity (whereas most games trade on ultimate goals, winners and losers, etc.). Play can be for play's sake. This distinction between play and games is instructive for our analysis of the following two design cases.

Interactive Tiles for Children's Play

In a project conducted in collaboration with two Danish companies and two other research institutes interested in designing interactive playgrounds, we participated in the design of simple interactive tiles for children's play. The original purpose of the collaboration was to find ways of creating technologically interactive play equipment with the (ultimate) aim of contributing towards reducing the prob-

23 Katie Salen and Eric Zimmerman, *Rules of Play: Game Design Fundamentals* (Cambridge, MA: MIT Press, 2004).

24 Hans Georg Gadamer, *Truth and Method* (London: Sheed & Ward, 2nd ed., 1979), 93.

lem of childhood obesity. It was thought that there might be design possibilities for increasing children's opportunities for physically active play without decreasing their opportunities for interacting with technology. Here, we will maintain our focus on the products in use—how children at play used the interactive tiles.

The tiles are very simple devices.[25] Measuring 30 x 30 cm in area, 6 cm in height, and weighing about 2 kg, they only have two states, and only do one thing. On their top surface, each tile has been fitted with nine two-state (blue and red) LEDs, and when the tile is stepped on, all nine LEDs change from their current state (e.g., red) to the other (blue). Each tile operates entirely independently of the others.

In the situation we describe here, fourteen of these tiles were delivered to a primary school's activity rooms and outdoor playgrounds, where school children (aged between 7 and 12) were free to play with them. The activities we detail here were spontaneous in the sense that the children engaged with the tiles without instructions or suggestions from the project team. In these cases, the tiles simply were placed at the school for the students to play with as they wished. Each of these "games" emerged from their play.

Figure 1
Sequence of children using the tiles as stepping stones.

Stepping Stones

One of the uses of the tiles was as something akin to "stepping stones." The tiles were spread apart on the floor, and children would step across from one to the other (see Figure 1). Children attempted to change the color of the tiles as they stepped onto them, before moving on to another tile. Virtually all of the children attempted to stay on the tiles without having to step on the gymnasium floor. A pair of girls made use of the colors of the tiles, only permitting themselves to stay on tiles that were blue. Red tiles were treated as "hot," and were jumped off of as soon as possible. These two girls ping-ponged around the tiles until they managed to land on a blue tile (which they attempted to step on lightly so as not to change its color to red). Other children played other games, such as trying to push each other off the tiles, hopping from one tile to the next trying to throw other children off balance in the process.

25 The design iteration of the tiles we discuss here was not the final product of the collaboration, but only an intermediate "provocateur" intended to enable the design teams to better understand children's play activities around technology.

Figure 2
Sequence of children playing with rows of tiles.

Rows of Tiles as Playing Fields

One unexpected property of the tiles emerged through our observations of the children's play. A number of the tiles' sole function (the ability to change color from red to blue and back again to red) was inconsistent, due to variations in the material tolerances of their construction. Sometimes when children stepped on a tile, it wouldn't change color. Then maybe, as they stepped off of it, the pressure of switching to one foot and transferring their weight as they moved would work to change its color to blue. This "inconsistency" proved to be consequential to a number of the uses to which the tiles were put. For example, several groups of children arranged a series of tiles into rows, "setting up" the lane by switching all of the tiles to red, for instance. On one occasion, two girls created such an arrangement with four tiles (Figure 2). They then took turns to run across all of the tiles, attempting to change the color of each tile as they stepped on it. Several times, however, at least one or two of the tiles would stubbornly remain red, in spite of the fact they were stepped on. This presented the next girl with a row that had "gaps" (one or more unchanged tiles). She then used the remaining pattern as a challenge: only step on the altered tiles. Multiple patterns of red and blue tiles emerged from a combination of the tiles' being used in this way and their functional inconsistency. These worked in concert to increase the challenge of the game.

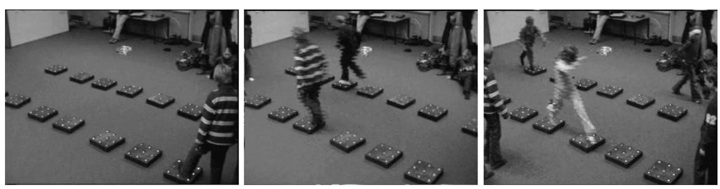

Figure 3
Sequence of images of the line race.

Line Race

One of the more organized uses of the tiles consisted of a "line race," (Figure 3) in which two rows of seven tiles were spread apart on the floor. The children "set up" the lines by switching all of the tiles to blue. They split into two groups, and each group lined up behind a row of tiles. The race was on, and one child after another would run across the row of tiles attempting to change the color of each tile as he or she ran. As before, however, the tiles' inconsistency again was consequential. Again, the children incorporated this feature into the rules of their game, whereby the next runner was not allowed to run across the tiles until the previous runner had successfully switched the color of each tile. Thus, the game became not just about which team could run across the tiles fastest, but about which team could manage to switch the colors of the tiles with the least "faults."

Tiles Discussion

This range of uses of the tiles draws out several features of their design and use that have direct bearing on interaction design research. First, the simplicity of the tiles (single function/dual state) belies the wide range of uses to which the children easily put them. Furthermore, what we see taking place with the tiles is not a simple function of anything that might have been consciously entertained by their designers. Latour's famous "anthropomorphization" of technologies as "nonhuman actors"[26] is poignant here, since we cannot completely account for the uses of these simple devices in terms of what their designers conceived for them.[27] Nor would we benefit from evaluating them with respect to their congruence with design intent.[28] The difficulty is in predicting precisely how the system will be put to use. What we see happening here is not simply a product of "what the designers imagined," nor of "the actual properties of the tiles," nor of "what the users created in context." There is a complex relationship between these that becomes visible in an analysis of use. This raises an important methodological point for design research: if we seek to understand the relationship between design and use, we cannot hope to account for this simply by studying designers, analyzing products, or understanding contexts of use; though clearly each of these has an important role to play in contributing to such an understanding. This recommends a fundamentally different (in situ) method of investigation than often is seen in studies of design-versus-use topics such as aesthetics.[29]

Secondly, we acknowledge the difficulties we encounter in attempting to analytically circumscribe the "system" that is evident in play. Recalling our previous discussion of games and play, we see both the stability and the tenuousness of the structures of the games that emerged during children's play with the tiles. It is clear from our cases that the children frequently used the tiles as a "system" in the sense that the uses to which the tiles were put were dependent on their relationship to other tiles, other children, and some "rules" of play that were explicitly or implicitly negotiated in use. The "systems" that existed here were ones that were brought into existence in use; created and sustained through the play. This underscores what may be a valuable point for interaction designers by virtue of the fact that these systems that we saw in play were not themselves designed. The point is that "spaces" for play (for multiple and varied uses of the tiles, or for competing and sometimes contradictory meanings of the tiles) were created through the openness of the design of the tiles. Furthermore, the fact that the tiles were not a part of a formal system (e.g., the tiles had no capacity for responding

26 Bruno Latour, "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts" in *Shaping Technology/Building Society,* Weibe E. Bijker and John Law, eds. (Cambridge, MA: MIT Press, 1992).

27 See also Thomas Binder, "Intent, Form, and Materiality in the Design of Interaction Technology" in *Social Thinking Software Practice,* Yvonne Dittrich, Christiane Floyd, and Ralf Klischewski. eds. (Cambridge, MA: MIT Press, 2002).

28 The designers' decisions with respect to form, function, dimensions, etc. of the tiles are not only consequential to the interaction, but also have delimited the design space to privilege and marginalize various forms of and parties to participation (e.g., some children may not weigh enough to be able to get the tiles to change color when they step on them; and wheelchair-bound children may be excluded from playing simply due to the shape of the tiles). More than one "script" is in play here, and we do not mean to absolve designers from the consequentiality of their decisions. Our focus is on the scripted nature of the play, however.

29 This marks a contrast to, for instance, work such as Paul Hekkert, D. Snelders and P.C.W. van Wieringen, "'Most Advanced, Yet Acceptable': Typicality and Novelty as Joint Predictors of Aesthetic Preference in Industrial Design," *British Journal of Psychology* 94 (2003).

to the states of other tiles) contributed to the wide range of uses we saw emerge in play, where the creation of "systems" was a negotiated feature of use.

Finally, we note the variability of the meanings of the tiles depending on their circumstances of use. Here we find ourselves unable to talk about the meaning of the tiles independently of their particular employments in the system in which they currently play a part. We can see this in instances where the colors of the tiles had specific meanings (e.g., blue tiles being "safe" and red ones being "hot"); also where the colors themselves did not have a meaning, but their state (changed or unchanged) relative to the game being played did (e.g., in the line races); and other cases where neither the colors nor the change of states had any particular use for the game being played (e.g., where the arrangement of tiles was used as a playing field). What we see taking place here is akin to the interdependence of elements in a "gestalt-contexture,"[30] where the meaning of each part of a figure is contingent upon its relation to the others. Yet in our case, we do not speak of a visual arrangement, but of a complex relationship between people, technology, and settings existing in use. The contextures we are considering (e.g., the different games) are in flux, as are the meanings of their parts (e.g., the tiles). Again, it makes little sense to ask which gives rise to the other. How it is that the properties of the tiles afford the specific games being played is in no sense a deterministic relationship; yet, clearly, had the technology taken a different form, these specific games would not have been possible.

Designer Toys for Interactive Games

In another project recently conducted in collaboration with Philips Research, three "toys" were designed as input devices for a video game.[31] A key aim for the designs was to provide physical and fun ways of interaction. While the original objective of the research was

30 Aaron Gurwitsch, *The Field of Consciousness* (Pittsburgh, PA: Duquesne University Press, 1964).

31 See Marcelle Stienstra, *Is Every Kid Having Fun? A Gender Approach to Interactive Toy Design* (Ph.D. thesis, Twente University, Enschede, The Netherlands, 2003).

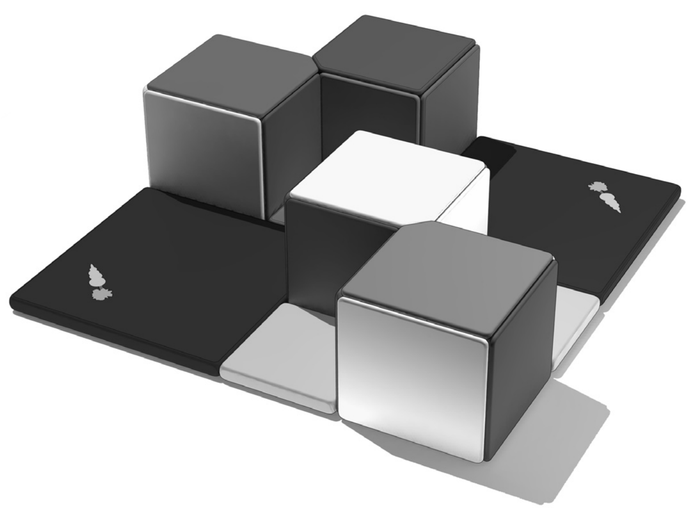

Figure 4
Twistyertouch interaction mat.

to investigate gender differences among the children's preferences for interaction input devices to the game, we will examine just one of these input devices here as a point of comparison with the tiles discussed earlier.

The input device, "Twistyertouch," is a "physicalized" play mat. On a 160 x 160 cm footprint stand, four cubes, each measuring 40 x 40 x 40 cm (see Figure 4). Each visible surface is covered with a soft cushion of a specific color. A button is positioned in the center of each surface, covered by a cushion. The button is activated by contact with the cushion, and there is audible feedback when a surface is activated.

In the context of the original study (where Twistyertouch was compared with two other toys), the play mat functioned as an input device to operate a fairly simple screen-based navigation/maze game. This game was displayed on a large screen positioned near the toy. The goal of the game was to direct a rabbit towards carrots that appeared and disappeared at different times and places in the maze. The children obtained points for each step that they managed to maneuver the rabbit through the maze, and "eating" a carrot earned bonus points. To move or change the direction of the rabbit, the children had to activate all the cushioned surfaces of a certain color. Next to the maze on the screen was a legend indicating the relationship between actions and cushion colors, and also how many (but not which) cushions had already been activated. This setup resulted in players constantly shifting their focus of attention: from the screen where the game was taking place, to the Twistyertouch where the interaction was taking place, and back again to the screen. Each game session lasted four minutes, and the the team was showed their final score.

Interacting with a device that was physically (proportionally) large, and collaboratively working towards the same goal—navigating the rabbit—created a structure in which the players interactively developed strategies to play. For example, children frequently divided the tasks they had to complete. One might look at the screen to see which color cushion had to be activated and how many there were left to be activated, while the other would look where these specific cushions could be found on the Twistyertouch in order to speed up the process. Children gave each other directions for which cushion to activate ("that one there, yeah great!"), and they would run around looking for specific colors, and shout them out to their friends ("Now pink!").

In a similar manner to the tiles discussed above, the construction of the Twistyertouch had consequences for play. For instance, the cushions on the play mat did not just hide the buttons underneath from view, but also made them more insensitive. Thus, the buttons did not always react when the cushions were hit. This encouraged children to play more aggressively: they sat on the cushions, punched them, jumped on them, kicked them, etc. in order to activate the buttons (see Figure 5). Players also made use of the fact that a cushion could only be activated in and around its center: they found out that they could move around mat by hanging on the edges of the cubes without touching the surface on the floor which also was equipped with buttons.

Figure 5
Sequence of interaction with Twistyertouch.

Children also discovered and seized upon the absence of certain rules of the game (i.e., moves that did not have consequences for play). During play, some children realized that it didn't matter if, in the process of trying to reach one specific cushion, they accidentally activated a cushion of another color, as long as not too many cushions of any one other color were activated. Thus, activating the "wrong" cushions became used as a means to move across the mat in order to activate the "right" ones more quickly—children would step on a blue tile on their way to kicking a yellow one in, saving them the time it would take to hop off the Twistyertouch and run around it to the next yellow cushion.

Twistyertouch Discussion

In this case, we can see that even in fairly tightly scripted games such as this (e.g., where there are defined rules, scores, and right and wrong moves), strategies emerge that make use of much more than merely the rules of the game. Players are able to create, define, and negotiate "styles" of play both by virtue of, and in spite of, the relatively restrictive script the game embodies.

In comparison to the tiles, we also see different aspects of interaction emerge with respect to the Twistyertouch. With respect to the structure provided by the game and the observability of novel strategies of play, it is much easier for notions such as "challenge" and "skill" to take a foothold, and, consequently, to be able to speak meaningfully of "engagement": the interaction we witness is competitive, purposeful, and deliberate. However, we also can see disjointedness between the site of interaction (the mat) and the site where the scripted meaning of the interaction (e.g., orienting/ moving the rabbit) plays out (i.e., on the screen). The Twistyertouch mediates the play in a manner that has no direct analogue in our case of the tiles. With the tiles, interaction *is the play* itself; activating a tile is identical and coterminous with making a move on the field of play. Thus, there is a qualitatively different relationship between the interaction and its meaning in the two cases; one that is quite clearly understandable as a consequence of the differences in the nature of the scripts inscribed in the products. With the Twistyertouch, relationships between cushions and actions in the game are specified in advance by the system.

This brings into relief one final contrast by virtue of our earlier discussion of "gestalt contextures." Where the tiles are, what they are (e.g., their state), and what they "mean" is locally and inherently tied to their place in the contexture. However, we see a noticeably different picture with respect to the Twistyertouch, where "fixed" uses have been inscribed into the mat-game system. Of course, the point is not to suggest that there is some optimum trade off (for designers or users) between scripting possibility and constraint, but instead that each affords different degrees and varieties of emergence.

Discussion

Considering emergence in use, we now might ask how should interaction design research proceed? What should it seek to study, and how should it be investigated? In a highly relevant discussion, Redström has charted the shift in focus of design research from the design of products to the design of the user experience.[32] He finds this move problematic for a number of reasons: that design cannot be rigorously grounded in existing use practice, since none exists prior to its implementation;[33] that designers therefore are left to predict the use of the product; and that actual use often can be radically and ironically different to anticipated use.

In a recommendation analogous in several respects to our discussion of "spaces for play," Redström advises designers not to "overdetermine" use. But just *how* designers are to do this, and do this well, remains an open question. One possibility is that of Gaver et al.,[34] who advocate ambiguity as a design virtue. Yet they also warn against designers using such openness as a license for creating frustrating and confusing products. The "ambiguous" design directions they promote (e.g., blocking expected functionality and using imprecise representations) may be a notable beginning. However, as with other design recommendations (c.f. principles of "good design" such as affordances, feedback, mapping, etc.), they are as easily prone to being misapplied and badly implemented as they are to being profitable as design advice.[35] Furthermore, we would argue that there is no guarantee that particular characteristics of any design (e.g., "inconsistencies") will be universally responsible for particular experiences of use (e.g., "spaces for interpretation"). As in the cases we have presented, the attribution of responsibility for specific forms of emergence in use to particular features of systems is an achievement of retrospective analysis, and one that may be unlikely to function unproblematically as a normative or prescriptive resource for designers.[36]

32 Johan Redström, "Towards User Design? On the Shift from Object to User as the Subject of Design."

33 See also Andy Crabtree, "Design in the Absence of Practice: Breaching Experiments."

34 W. Gaver, Jacob Beaver, and Steve Benford, "Ambiguity as a Resource for Design" (paper presented at Proceedings of CHI 2003, Ft. Lauderdale, FL, 2003).

35 Grudin's discussion of the pitfalls of "consistency" as a design guideline is important in this respect. See Jonathan Grudin, "The Case against User Interface Consistency," *Communications of the ACM* 32:10 (1989).

36 This situation is analogous to the way "loopholes" in bureaucratic systems often are unforeseeable consequences of rules and procedures implemented on account of existing and anticipated cases.

Surely, a hazard endemic to operating with the subtle characterizations of the interrelationships between design and use articulated by theorists such as Akrich is their obstinacy to translate into prescriptive design guidelines.[37] This does not mean that designers cannot employ understandings of how existing forms of emergence arise in use to inform new designs. However, it does suggest that the ways in which novel forms of interaction emerge can only be partially understood with reference to aspects of the product under the control of designers; moreover, emergence is inherently tied to the *relationship* between product and context brought into being in use. In an important sense, designers create the rules within which users develop emerging modes of use;[38] but as we have argued, this is a constitutive rather than a deterministic relationship. Still, we maintain that such theoretically informed forms of analysis are valuable in spite of the fact they do not easily map to design recommendations.

For one thing, they enable designers to rethink inherited conceptualizations, such as what design work actually consists of, including the role of the designer. This is valuable not because existing conceptions (such as Norman's) are misguided or unhelpful, but because alternative perspectives can open new horizons to design; encouraging designers to reassess the nature of their own work and responsibilities. We have tried to illustrate the potential value of moving beyond conceptions of design work as solving problems and meeting users' needs or unarticulated desires. In our cases, design for emergence was not achieved by virtue of designers having a clear idea of such things in advance, but rather was tied to the creation of spaces for meaning to arise in use. We hope that such considerations might work to challenge the design of interactive technologies toward novel styles of interaction, whether they are inscribed into artifacts, or the result of users' creative appropriation of the spaces left unscripted by designers. Furthermore, the analysis reveals how products come to be as they are in use—whether enjoyed, tolerated, unpredictable, frustrating, or useful. Analysis of use, with the aid of theory, becomes a resource for designers to gain a view of how products and systems can and should be different. The diverse body of extant theory in cognate disciplines, coupled with an empirical examination of sites of use, can enable designers to better conceptualize the complex networks of relations that technology and its deployment bring into being.

Perhaps paradoxically, this understanding leads us to reconsider the welcome move towards "understanding context" prior to designing for a setting. In cases such as ours, the introduction of technology is itself an introduction of practice (i.e., no comparable practices exist in the absence of the technology's implementation).[39] Thus, no *prior* study could furnish us with this understanding of context. As we have seen here, many of the observations of the use of the toys and tiles are neither products of the "context" that

37 Compare Woodhouse and Patton, "Design by Society: Science and Technology Studies and the Social Shaping of Design."

38 See also Steve Woolgar, "Configuring the User: The Case of Usability Trials" in *A Sociology of Monsters: Essays on Power Technology and Domination,* John Law, ed. (London: Routledge, 1990).

39 Andy Crabtree, "Design in the Absence of Practice: Breaching Experiments."

existed before their introduction (however that might be analytically delineated); nor are dependent solely on the actual properties (e.g., form, interaction, functions) of the specific technology; but of the tenuous "context" created and sustained in use. It is this "context" that affords the possibilities and actualities of interaction; and this context that must be examined to inform design. This, at least, makes a clear case for where and how interaction design research must look to understand "interaction."

Finally, our discussion also may serve as a recommendation to design researchers to be wary of attempts to romanticize, semanticize, or abstract platonic interaction styles, aesthetics of form or interaction, the "emotional" content of technologies, or a host of other topics currently fashionable in interaction design research. Appreciating the inherent context-dependence of the meanings of technology and their relation to the forms of emergent interaction exhibited in use has clear methodological implications for the types of questions we can expect research to illuminate, and the types of settings we must inspect for their clarification. The manner in which we understand these matters demands that research appreciate how such notions take their definitive sense locally, not globally.

The Design of Implicit Interactions: Making Interactive Systems Less Obnoxious

Wendy Ju and Larry Leifer

Introduction

Imagine, for a second, a doorman who behaves as automatic doors do. He does not acknowledge you when you approach or pass by. He gives no hint which door can or will open—until you wander within six feet of the door, whereupon he flings the door wide open. If you arrived after hours, you might stand in front of the doors for awhile before you realize that the doors are locked, because the doorman's blank stare gives no clue.

If you met such a doorman, you might suspect psychosis. And yet this behavior is typical of our day-to-day interactions not only with automatic doors, but any number of interactive devices. Our cell phones ring loudly, even though we are clearly in a movie theatre. Our alarm clocks forget to go off if we do not set them to, even if we've been getting up at the same time for years. Our computers interrupt presentations to let everyone know that a software update is available. The infiltration of computer technologies into everyday life has brought these interaction crises to a head. As Neil Gershenfeld observes, "There's a very real sense in which the things around us are infringing a new kind of right that has not needed protection until now. We're spending more and more time responding to the demands of machines."[1]

These problematic interactions are symptoms of our as-yet lack of sophistication in designing interactions that do not constantly demand the input or attention of the user. "Implicit interactions"—those that occur without the explicit behest or awareness of the user—will become increasingly important as human-computer interactions extend beyond the desktop computer into new arenas; arenas such as the automobile, where the driver is physically, socially, or cognitively engaged. Traditional HCI—that involving a command-based or graphical user interface-based paradigm—has focused on the realm of "explicit interactions," where the use of computers and interactive products relies on explicit input and output. The values and principles that govern good desktop computing interactions may not apply when we apply computing to the products that populate the rest of our lives.

1 Neil Gershenfeld, *When Things Start to Think* (New York: Henry Holt, 1999), 102.

We humans have an abundance of experience in implicit interactions. We successfully employ them in our daily interactions without conscious thought: we modulate our speaking volume based on ambient noise level, use smaller words when explaining things to children, and hold the door open for others when we see that their arms are full. These accommodations do much to smooth our day-to-day interactions with one another, and yet are made without an explicit command.[2] By understanding how implicit interactions between humans help to manage attention, govern expectations, and decrease cognitive load; we are able to cross-apply solutions from one domain to another.

In this article, we present a framework for implicit interactions to enable human-computer interaction researchers and designers to understand the ways in which implicit interactions are distinct from explicit interactions, and to provide guidance on when different types of implicit interactions are useful. We also introduce the use of implicit interaction patterns and analogues as a design methodology. This method leverages the domain-independence of the implicit interaction framework to enable interaction designers to draw generalizations about interaction technique across application domains. Together, the implicit interaction framework and its associated methodology lay the groundwork for an emerging area of applied design research[3] focused on improving the interactions between people and computer-based systems embedded in the world.

Approach

By outlining a design method that is useful in creating a broad class of interactions, we seek to complement technology-based approaches (which focus, for instance, on sensors and architectures that enable implicit interaction), or analysis-based approaches (which would investigate implicit interaction through studies and controlled experiments) towards implicit interaction design. This design-based approach has two main objectives: to be "generative"—that is, to guide designers in a constructive fashion in designing implicit interactions—and to be "generalizable"—that is, to suggest techniques and methods that are applicable to interaction designers working on a wide array of ubiquitous computing scenarios. Just as toolkits provide a common architecture and library for software developers working on similar classes of applications,[4] we want the implicit interaction framework and methodology to help designers generate designs for similar types of interactions.

Our approach differs from that taken by many researchers working in the areas of ubiquitous computing. The usual approach is to use ethnography and contextual inquiry techniques to characterize the ways in which the specific domain in question is unique, and then to use some logic or reasoning system to deploy this domain-specific knowledge. Such solutions to knowing when the cell phone should vibrate silently, or when the alarm clock should chime, focus

2 Jakob Nielsen, "Non-Command User Interfaces," *Communications of the ACM* 36 (April 1993): 83–99.

3 Richard Buchanan, "Design Research and the New Learning," *Design Issues* 17:4 (2001): 3–23.

4 Brad Meyers, Scott Hudson, and Randy Pausch, "Past, Present, and Future of User Interface Software Tools," *Transactions on Computer-Human Interactions* 7:1 (2000): 3–28.

on solving these problems by making devices "smarter." While this approach is generative, it is rarely generalizable because the expert knowledge of how to behave in one situation does not translate to any other. But this absorption with modeling human intelligence gives short shrift to the richness of human interactions. It focuses on being "logical" rather than "courteous." What if our true talent as human interactants is less a wealth of situation-specific intelligence and more a measure of situation-independent suave?

At the other end of the spectrum is the surplus of design principles that aim to achieve implicit interaction through platitude. Cooper and Reimann's "About Face 2.0," for example, provides the following guidance for designing considerate software: "Considerate software takes an interest. Considerate software is deferential. Considerate software is forthcoming.... Considerate software doesn't ask a lot of questions. Considerate software takes responsibility. Considerate software knows when to bend the rules."[5] This is not bad advice—it certainly is general enough—but these guidelines do not actually help designers determine when an interactive system should take an interest, and when it should not ask a lot of questions. It is important to provide a vocabulary and an approach that allows designers to more easily reason about what degree of implicitness or explicitness is desired in the situation they are designing, and to hypothesize how they might create the appropriate experience.

A Framework for Characterizing Implicit Interactions

This framework models interactions as the exchange between a person (sometimes called the user or actor) and a machine (sometimes referred to as the computer, robot, or, more generically, the system). This is limited to describing dyadic relations, but provides a useful basis for modeling basic interactions.

Implicit interactions enable communication without using explicit input or output. One way that an interaction can be implicit is if the exchange occurs outside the attentional foreground of the user. This occurs in traditional computing—when the computer auto-saves your files, or filters your spam e-mail, for instance—as well as in ubiquitous computing interaction. The other way that an interaction can be made implicit is if the exchange is initiated by the computer system rather than by the user—if the computer alerts you to new mail, or when it displays a screensaver. (It may seem counter-intuitive that something that grabs your attention could be implicit, but it is important to remember that the interaction is based on an implied demand for information or action, not an explicit one.)

5 Alan Cooper and Robert Reimann, *About Face 2.0: The Essentials of Interaction Design* (Indianapolis, IN: Wiley, 2003), 184.

The implicit interaction framework (Figure 1) divides the space of possible interactions along the axes of attentional demand and initiative. Attentional demand is the attention demanded of the user by the computer system. Interactions that demand the users attention are *foreground interactions*, and interactions that elude the user's attention are *background interactions.* Initiative is an indicator of who—and to what degree—is initiating an interaction. Interactions initiated by the user are *reactive interactions*, and interactions initiated by the system are *proactive interactions.* By characterizing interactions in this way, we are able to generalize about the capabilities and features of whole classes of interactions in a domain-independent fashion.

The following are descriptions of interactions typified by each quadrant:

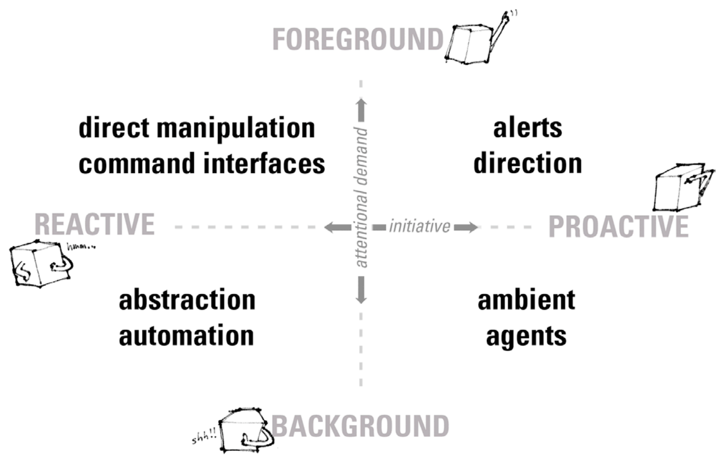

Figure 1
The Implicit Interaction Framework shows the range of interactive system behaviors.

The Framework in Action

To better understand the range of implicit interactions, let us consider this example: Our friend Terry sends us a link to a funny animation that can be found online. To play the animation, we need a Macromedia® Flash plug-in installed on our computer. The following cases show different ways that the plug-in may be installed:

> **CASE 1:** We see that the animation does not work. We deduce that we need the plug-in. We find, download, and install the plug-in.

This is a classic example of explicit interaction. This is far from a unilateral activity on our part, because the computer is involved throughout this process, but we are actively engaged in diagnosing, deciding, and performing each step along the way.

CASE 2: We see that the animation does not work. We deduce that we need the plug-in, and ask the Web browser to find, download, and install the plug-in.

CASE 3: Our Web browser shows that our animation does not work because we are missing a plug-in. We find, download, and install the plug-in.

The second and third cases highlight the different ways interactions can be implicit. In case 2, we actively perform the task of problem observation and diagnosis, but the individual steps of getting the plug-in installed are abstracted away so we don't have to attend to each step. In case 3, the browser proactively identifies the problem and suggests a solution, although we have to go through the steps to implement it.

Case 2 is an example of *abstraction;* the plug-in installation occurs in the background, so that we don't have to actively and explicitly perform each step. Case 3 is an example of *alert,* where the interaction is implicit in that the system proactively diagnosed and informed me of the need for the plug-in. These cases illustrate how attentional demand and initiative affect the implicitness of the interaction.

CASE 4: Our Web browser shows us that our animation does not work and offers to find, download, and install the plug-in. We accept the offer, and the plug-in is installed.

CASE 5: Our Web browser sees that we are trying to play an animation that we do not have the plug-in for, and lets us know that it is automatically finding, downloading, and installing the plug-in.

CASE 6: Our Web browser sees that we are trying to play an animation that we do not have the plug-in for, and automatically finds, downloads, and installs the plug-in in a background process.

These three cases show increasing degrees of proactivity and *presumption* on the part of the Web browser, and decreasing degrees of attentional demand. In case 4, there is a fair amount of demand on our attention because we need to actively accept an offer. In cases 5 and 6, the plug-in is installed without any activity on our part, but the last case is more implicit because no feedback is offered. Although our actions in both cases are the same, case 6 is more presumptuous because we do not have the opportunity to oversee and possibly cancel the task.

CASE 7: Our Web browser anticipated that we might want to play a Flash animation someday, and already has downloaded and installed the plug-in.

This last case is the most implicit interaction. In fact, with so much presumption and so little visibility, this last interaction may hardly be considered an interaction at all, since there is no activity or awareness on our part.

There is a range of ways to accomplish the task of installing the Flash plug-in with different degrees of attentional demand and proactivity. Which is the best? It depends a lot on the situation: How capable is the user of installing this plug-in? How much control does the user want over disk space or network bandwidth? How concerned is the user about security? Just how funny is the animation Terry sent, anyway? Most plug-ins use a design such as the one in Case 4 because it provides a happy medium.

As this example shows, although we speak of "implicit interactions," it is more accurate to speak of interactions being more and less implicit. Within the course of a task, different aspects of the interaction—the diagnosis, the action, and the feedback—may be more or less implicit. Even though this example reflects a human-computer interaction, the issues that we raised around the implicitness are reflective of the style of the transaction rather than the characteristics of the computer, and thus transcend human-computer interaction to interaction in general.

Now we will examine the two dimensional variables in greater detail:

Attentional Demand

Attentional demand generally is described by the degree of cognitive or perceptual focalization, concentration, and consciousness required of the user. "Foreground interactions" make greater attentional demands on the user, while "background interactions" do not make such demands and, in fact, elude notice.

A more complex definition of attention demand also needs to account for spatiality (as Goffman did in drawing a distinction between "frontstage" and "backstage" interactions), breadth (with many stimuli or just one), or intensity, among other things. This complexity reflects an increasing sophistication in understanding attention itself. Cognitive neuroscientists are starting to believe that attention actually is a catch-all grouping of widely diverse mental functions and phenomena.[6] However, a broad, commonsense understanding of attention allows us to reason sufficiently about our interactions with other humans, and so it is operationally sufficient to design with.

6 Patrick Cavanagh, "Attention Routines and the Architecture of Selection" in *Cognitive Neuroscience of Attention,* Michael I. Posner, ed. (New York: Guilford Press, 2004): 23–24.

Attentional demand can be manipulated by adjusting the perceptual prominence of objects. This may be done through visual organization techniques such as contrast, hierarchy, and weight,[7] as well as more dynamic means such as pointing or placing.[8] Interaction design research on the use of such techniques to present ambient information to users engaged in some other task has been pursued at the MIT Media Lab[9] and Berkeley's Group for User Interface Research,[10] among others.

Another way to change the degree of attention demanded is through "abstraction." By combining elements into a larger whole, the user is presented with less detail. "Chunking" is an example of an abstraction technique through which experts are able to comprehend complex situations (such as the state of a chessboard) with greater ease because they are able to parse the scene into familiar subcomponents.[11] Gestalt psychology has demonstrated that this process of chunking leads an "integrating of awareness," where people are able to identify a whole (say a particular person's face) without being able to identify the details that make up the whole.[12]

This discussion of attentional demand may resonate with those familiar with Bill Buxton's concept of attentional ground: [13] "What we mean by foreground are activities which are in the fore of human consciousness-intentional activities. Speaking on the telephone or typing into a computer are just two examples." Buxton's definition of foreground only overlaps with the left half of the implicit interaction framework, because he only considers the realm of user-initiated interactions—typing on a keyboard or switching on a light—Buxton's definition conflates attention with intention. This definition is inadequate for describing device-initiated interactions—a cell phone ringing or an automatic door opening. These interactions clearly take place in the foreground, but are not at all intentional on the part of the user. Decoupling attention from intention gives us a separate dimension, "initiative."

Initiative

The distinction of who initiates an interaction is critical. If a waiter refills your coffee because you ask him to, that is a *reactive* response to your explicit request. However, if the waiter refills your cup because he sees that it is empty, this interaction becomes implicit. Even if the *proactive* act of pouring the coffee might be in your attentional foreground, the waiter is responding to a projected request for more coffee. (For our purposes, we are only analyzing the interaction on a pragmatic level. Sociologists such as William Foote Whyte[14] have commented on the ways that the server's actual motivations for action are complex and multilayered—the waiter also may be responding to a desire for a tip, for instance, or to make her way around her circuit in an efficient manner. This sophistication of analysis is not needed for the design of implicit interactions.)

7 Luke Wroblewki, "Visible Narratives: Understanding Visual Organization," *Boxes and Arrows* (New York: AIGA, January 20, 2003).

8 Herbert H. Clark, "Pointing and Placing" in *Pointing: Where Language, Culture, and Cognition Meet,* Kita Sotaro, ed. (Mahwah, NJ: Lawrence Erlbaum, 2003), 243–68.

9 Craig Wisneski, Hiroshi Ishii, and Andrew Dahley, "Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information," *International Workshop on Cooperative Buildings* (1998).

10 Tara Matthews et al. "A Toolkit for Managing User Attention in Peripheral Displays," *Proceedings of ACM Symposium on User Interface Software and Technology,* ACM Press 17 (2004): 247–56.

11 William Chase and Herbert Simon, "Perception in Chess," *Cognitive Psychology* 4 (1973): 55–81.

12 Michael Polanyi, *The Tacit Dimension* (London: Cox & Wyman, 1966).

13 William Buxton, "Integrating the Periphery and Context: A New Model of Telematics," *Proceedings of Graphics Interface* (1995): 239–46.

14 William Foote Whyte, *Human Relations in the Restaurant Industry* (New York: McGraw-Hill, 1948).

Initiative is salient in situations in which actors are working together to accomplish a task. From the perspective of those championing direct manipulation or autonomy, joint action is suboptimal because it requires negotiation and coordination. However, it is far easier to think of successful examples of joint actions than terrific tools or perfectly autonomous objects. "Every day, we engage in activities in which we have to coordinate with others to succeed," says Herb Clark. "Face to face, we have systematic, economical, and robust techniques of arranging for joint activities." [15] One can even argue that we can experience readiness-to-hand in interaction with others; certainly we can contrast the ease and transparency with which we can buy a shirt at Macy's with the tortuous process of buying things in a foreign country with a different language and customs. In fact, it is possible to imagine optimal interactions at every point along the initiative continuum. The challenge is in knowing what interaction is appropriate for the situation at hand.

Proactive objects operate in a realm of greater presumption, and so it is common that they need ways of seeing, discerning, and reasoning about the world.[16] This explains why most forays into proactivity, such as the research performed at Microsoft Research,[17] the University of Karlsruhe,[18] and Georgia Tech,[19] have been oriented on the technological issues of sensing, aggregating data, developing user and task models, and performing inference.

And yet the solution for proactive interaction cannot lie in technology alone. People, for all their vaunted intelligence, make inference mistakes all the time, and usually are forgiven. Why is it, then, that interactive products such as the Microsoft Office Helper are so roundly criticized for guessing incorrectly what users are trying to do? It is probably because "Clippy" is untrained in the art of what Goffman calls "facework," sometimes called social graces, *savoir-faire,* diplomacy, or social skills.[20] Since the days of expert dialogue systems, human-computer interaction researchers have considered how "mixed-initiative" interplays between proactive and reactive actions, from both users and computers, can contribute to a project or an understanding." [21] Similar negotiations are necessary on an interaction level to help systems communicate intended actions, and enable user override.

When people go out on a limb, taking initiative in the face of uncertainty, they engage in compensating measures; hedging their actions with techniques such as overt subtlety (where actors make a show of how unobtrusive they are trying to be) or preemptive apology (where actors may bow their head, scrunch up their faces, or raise their shoulders as they execute an action to indicate an apology if their initiative is unwelcome). One could easily imagine, for instance, that recent research on interruptions at Carnegie Mellon[22] and Microsoft Research,[23] which have focused primarily on *when* to

15 Herbert H. Clark, "Arranging To Do Things with Others," *Proceedings of ACM Conference on Human Factors in Computing Systems* (1996): 165–67.

16 David Tennenhouse, "Proactive Computing," *Communications of the ACM* 43:5 (May 2000): 43–50.

17 Eric Horvitz, Carl Kadie, Tim Paek, and David Hovel, "Models of Attention in Computing and Communication: From Principles to Applications," *Communications of the ACM* 46 (2003): 52–59.

18 Albrecht Schmidt, "Implicit Human Computer Interaction through Context," *Personal Technologies* 4:2 and 3 (Springer Verlag, June 2000): 191–99.

19 Daniel Salber, Anind K. Dey, and Gregory D. Abowd, "The Context Toolkit: Aiding the Development of Context-Enabled Applications," *Proceedings of the 1999 Conference on Human Factors in Computing Systems* (1999): 434–41.

20 Erving Goffman, *Interaction Ritual* (New York: Pantheon, 1967), 13.

21 Eric Horvitz, el al., "Models of Attention in Computing and Communication: From Principles to Applications": 52–59.

22 James Fogarty, et al., "Examining Task Engagement in Sensor-Based Statistical Models of Human Interruptibility," *Proceedings of the ACM Conference on Human Factors in Computing Systems* (2005): 331–40.

23 Mary Czerwinski, Edward Cutrell, and Eric Horvitz, "Instant Messaging: Effects of Relevance and Time," *Proceedings of HCI 2000,* XIV Vol. 2 (British Computer Society, 2000), 71–76.

interrupt, could be complemented by research on *how* to interrupt. There are conventional ways to act proactively, even in the face of uncertainty, and these are a matter of sociable design rather than technological intelligence.

Implicit Interaction Design Methodology

Because implicit interactions occur outside of the user's notice or initiative, they can be challenging to design: it is insufficient to project what commands we might issue as users and make them possible. Instead, it is important that the designers of implicit interactions pay greater attention to the interplays between interactants. Our design methodology for implicit interactions uses interaction patterns to help designers model interactive object behaviors of know-how about how to engage in everyday interactions with other people.[24]

Interaction Patterns

The patterns of everyday interactions have been studied by those in other disciplines. Sociologists, for instance, represent what Goffman calls the "strips of activity" as detailed narratives, setting the general context and describing specific behaviors.[25] Artificial intelligence researchers, such as Roger Schank and Robert Abelson, choose to use "scripts"—predetermined, stereotyped sequences of actions that define well-known situations.

Like pattern languages, these interaction patterns provide templates for solutions that designers can share with one another. However, while design patterns suggest high-level approaches to specific classes of design problems, based on previous successful designs, our interaction patterns provide detailed instructions for the oft-implicit communications between actors, and are derived from observations in the world.

Here is an example two interaction sequences, one with a doorman, and another, patterned after the first, with an automatic door that mimics the doorman's implicit behaviors analogously:

SETTING: On a sidewalk at the entrance to a building in the middle of the block.

ROLES: Doorman, Passerby

SEQUENCE:
1 Doorman: [stands in front of the door, wearing a red uniform]
2 Passerby: [walks down street, on a path that will pass the door]
3 Doorman: [spots person walking down street]
4 Passerby: [notices doorman with red finery in front of the door, but keeps on walking]

24 Goffman, *Interaction Ritual,* 13.

25 Roger Schank and Roert Abelson, *Scripts Plans Goals and Understanding* (Hillsdale, NJ: Lawrence Erlbaum, 1977), 41.

5 Doorman: [puts gloved hand on door handle]
6 Passerby: [slows down a little, and looks into the doorway]
7 Doorman: [opens door slightly]
8 Passerby: [keeps walking past door; turns to look down street]
9 Doorman: [lets door shut, and takes hand away from the door handle]

SETTING: On a sidewalk at the entrance to a building in the middle of the block.

ROLES: Door, Passerby

SEQUENCE:
1 Door: [exists, with sign that says "Automatic Door"]
2 Passerby: [walks down street, on a path that will pass the door]
3 Door: [sensors notice motion down the street]
4 Passerby: [notices door frame, and keeps on walking]
5 Door: [makes a soft motor hum noise, as if preparing to open]
6 Passerby: [slows down a little, and looks into the doorway]
7 Door: [opens a little, jiggling its handle]
8 Passerby: [keeps walking past door; turns to look down street]
9 Door: [lets door shut]

In this scripted example, the doorman employs proactive, low-attention techniques to signal his capability for opening doors. He did this through *overt preparation,* when he put his gloved hand on the door handle, and through an *enactment technique,* by pulling the door open a little as a suggestion. An interaction designer designing an automatic door can use the doorman pattern to motivate questions such as how the door draws attention to itself, how it communicates its role as a portal, and how it introduces its affordance. Such steps sometimes can be accomplished implicitly: the door's mere physical form serves to draw attention and communicate its "door-ness." The designer also can look for clever ways to achieve the effects of each step: by opening a little when a person walks by, for example, the automatic door can simultaneously draw attention, define its role as a door, and introduce its ability to open automatically by softly humming in overt preparation or jiggling its handle as enactment. The interaction pattern helps designers to determine the roles, setting, and sequence of the interaction to be designed. The interaction analogues allow the designer to imagine functionally equivalent actions, mapping the capabilities of the automatic door against the techniques employed by the doorman, without slavishly and literally replicating his actions.

Issues for Implicit Interactions

Problem Selection vs. Problem Representation

What types of design problems are implicit interaction problems? We introduced implicit interactions by stating that they may be employed when the user is focused on something other than trying to get an interactive device to do what he or she wants; perhaps because the user is physically, socially, or cognitively engaged, or because he or she is not cognizant of what direction that the interaction should take. These are instances where the design requires some degree of agency on the part of the interactive system.

That said, whether a design requires agency is a matter of the designer's point of view. A car, for example, may be said to be driven through the direct manipulation of the steering wheel, gas, brake, and clutch pedals. However, one also can view the interaction between car and driver as a series of sometimes overlapping transactions—that the driver requests greater speed by pressing on the gas pedal, or a change in direction by turning the steering wheel. This second view grows more apt as steer-by-wire technology for automobile operation becomes prevalent. It may be senseless, from a design standpoint, to speak of which view is right or wrong, but it is evident that the adoption of different points of view suggests very different types of solutions.[26]

For this reason, it is useful to view the implicit interaction framework less as a hammer, and more as a lens. From the design research perspective, the implicit interaction framework is a type of problem representation, a means of representing interaction problems so as to make the solution apparent.[27] The central goal of this paper is not to advocate the design of a class of interactive products ("Make implicit interactions!"), but rather to champion a particular approach to designing interactions ("Consider your design as an implicit interaction!"). As Tom Erickson suggests, "There are multiple perspectives from which interaction designers can analyze the sites or situations with which they are confronted, and that designers will fare best when they are able to pick up one lens, then another, and then a third."[28] It is up to the designer to employ the framework and methodology in a mindful manner.

Interdisciplinarity and Appropriation

Part of the challenge of implicit interaction design is making explicit that which is invisible in day-to-day life. One way to do this is for interaction designers to employ sociological methods to understand human-human interactions, and then translate these interactions to novel human-product interactions.

26 Terry Winograd and Fernando F. Flores, *Understanding Computers and Cognition: A New Foundation for Design* (Boston, Addison Wesley Publishing Company) 1986) 77.

27 Herb A. Simon, *The Science of the Artificial* (Cambridge, MA: The MIT Press, 3rd ed., 1996), 132.

28 Tom Erickson, "Five Lenses: Towards a Toolkit for Interaction Design 1," *Foundations of Interaction Design* (New York: Lawrence Erlbaum Associates, 2005).

The application of sociology to human-product interactions is nothing new. Bruno Latour, for instance, enjoyed anthropomorphizing door springs to argue that sociologists need to address the role of nonhumans in their accounts of society:

> For sure, springs do the job of replacing grooms, but they play the role of a very rude, uneducated, and dumb porter who obviously prefers the wall version of the door to its hole version. They simply slam the door shut.[29]

In this paper, we have reversed Latour's approach, objectifying the role of human actors to make products that are less obnoxious, making doors that act not as wall or hole, but as a courteous groom. Designers have broadly employed ethnographically informed practices for decades to inform the user needs or context of the design. This work simply extends the use of ethnography to the generation of positive models for product behavior. We also drew on methods from communications, psychology, and linguistics. For instance, this approach also can be seen as the interactive extension of Reeves and Nass's Media Equation: we expect people to interact most successfully with interactive products in the same manner they interact with other people.[30]

As these techniques are appropriated for design, they are necessarily transformed. The value structures behind the social science methods we use cannot but change when the intended outcome shifts from production of knowledge or performance to production of new interactive systems.[31] We are not claiming that this work is the same as, or a substitute for, the practice of social science by social scientists, or the practice of art by artists within these same domains. At the same time, it is important to recognize that designers *need* to appropriate these techniques and make them their own in order to meet their aims.

In his discussion on studying doormen in New York City, sociologist Peter Bearman notes: "For the founding fathers of sociology,...the city posed special problems for the generation of social order. In contrast to the thick, multivalent, and sustained interactive world of the country, urban interactions were seen as thin, episodic, instrumental, and univalent."[32] (Bearman goes on to argue that urban environments are, in fact, as rich and thick as any other environment.) For designers of interactive systems, however, the desire may very well be to study thin, episodic, instrumental, and univalent interactions, and to ignore layers of motivations and depth of meaning, because the very lack of rich humanity that makes these uninteresting transactions for social scientists makes them the most promising targets for interactive design. Thus, the use of interdisciplinary techniques by designers can offer something original to the world of interaction design.

29 Bruno Latour, "Where Are the Missing Masses? The Sociology of a Few Mundate Artifacts" in *Shaping Technology/Building Society: Studies in Sociotechnical Change*, Wiebe Bijker and John Law, eds. (Cambridge, MA: MIT Press, 1992), 225–58.

30 Byron Reeves and Clifford Nass, *The Media Equation* (New York: Cambridge University Press, 1996).

31 Paul Dourish, "Implications for Design" in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York: ACM Press, 2006), 541–50.

32 Peter Bearman, *Doormen* (Chicago: University of Chicago Press, 2005), 17.

Conclusion

As interactive devices continue to permeate our world, it is up to the interaction designers to correct their obnoxious habits in order to make them more usable and useful. Well-designed, implicitly interactive devices can allow us to reap the benefits of computation and communication away from the desktop, assisting us when we are physically, socially, or cognitively engaged, or when we do not know what should happen next. Designed poorly, these same devices can wreck havoc on our productivity and performance, creating irritation and frustration in their wake. By taking stock of what it is we humans do when we work with one another, and using a bit of creativity in applying these lessons to the machine world, we can help make this next generation of interactive devices welcome in our world.

To this end, we have presented a framework for implicit interaction that characterizes interactions based on attentional demand and initiative—factors that are pertinent to any interaction, regardless of domain. We have applied this framework to the use of implicit interaction patterns, which allow designers to apply techniques and solutions from one domain as a template for the analogous solution for another. This framework and methodology can be used by designers as a lens on their interaction design problems, and help them leverage existing linguistic, sociological, or ethnographic techniques to the end of designing better human-computer interactions.

Because implicit interactions have convergent features due to the constraints imposed by the human in the loop, knowledge about the interactions can be generated and generalized—key components in any area of academic research. This transmissibility of solutions from one domain to another also enables design solutions to be passed from one design researcher to another, enabling designers of interactive objects to develop generalized interaction patterns for different classes of interactions.

User Interface Design Principles for Interaction Design

Adream Blair-Early and Mike Zender

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In recent years, the number of computationally-based devices has grown rapidly, and with them the number of interfaces we encounter. Often, the face for today's product or service is, at first touch, an interface. While the pervasiveness of the interface might present a minor challenge for the majority, for those with little previous knowledge or accessibility limitations the challenge can be insurmountable. In many cases, the way we access and use, and even the degree to which we rely on technology, may be vastly different from generation to generation.

As the number of interfaces and the diversity of users grow, the need for effective interface design increases. Clocks on VCRs and DVD players flash at users insistently demanding to be reset, a mute testimony to the failure of the interface. Designers commonly mimic standard interface design elements such as icons and metaphors, or create flashy interfaces that may appeal visually, but often at the expense of user understanding and functionality. Despite mimicry, creativity, new technology, and a steadily growing need, interfaces are mired in paradigms established decades ago at a time when user interface was more a computer novelty than a part of everyday life.

Thus far, pundits, consultants, and authors have attempted to improve interface design primarily by exploring and analyzing existing patterns of interface design, or by defining desirable end-user experiences.

One example of a detailed analysis of an existing pattern is the Nielsen Norman Group's 106-page report, "Site Map Usability."[1] A site map is a means for quickly gaining an overview of a Web site. The report mentions a principle in the first sentence of the executive summary: "Help users understand where they are"; then analyzes in great detail a specific means or pattern for meeting that need such as "Web site maps," delivering twenty-eight guidelines "to improve site map usability." Another recent example is Duyne, Landay, and Hong's book *The Design of Sites*,[2] which focuses on using existing patterns to improve Web interface design. As helpful as such approaches are, the examination of an existing pattern such as the site map, and a detailed recipe for the execution of that pattern, is not designed to stimulate innovation.

1 Nielsen Norman Group, Site Map Usability (Fremont, CA, 1998).
2 Douglas K. van Duyne, James A. Landay, and Jason I Hong, *The Design of Sites* (Boston: Addison-Wesley, 2003).

Two examples of desirable end-user experiences are the often cited "easy-to-use" and "intuitive." These recommendations have two problems: they are too vague to be useful and, as final experiences, they provide no indication of how they may be achieved. Jef Raskin, in his 1994 article noting the vagueness of "intuitive interface" as a measure of user experience,[3] maintains that the common usage of intuitive interface really means "familiar"; that is, an interface that resembles or is identical to something else. However, if familiarity is the criteria for success, then creativity and novelty certainly will suffer. In a field in which improvement is needed, a focus on familiarity will simply reinforce an unacceptable status quo. In his article, Raskin notes the tension between improvement and familiarity, suggesting that if intuitive is defined as familiar then "'Intuitive' may well turn out to be one of the worst qualities it (a new interface paradigm) can have."[4] Because Raskin wrote in 1994, it may be tempting to think that such advice is passé, but this is not true. Catherine Courage and Kathy Baxter's recent book *Understanding Your User*,[5] published in 2005, is intended to be a practical guide to user requirements. It defines useable products as "easy to learn."[6] Even if "easy to use/learn" or "intuitive" were defined precisely, it still would describe an outcome without offering the means to achieve it.

The Need for Principles

W. Ross Winterowd, in his introduction to *Contemporary Rhetoric*, writes, "A conceptual framework is a schema—sometimes diagrammatic—that serves two purposes. It allows one to organize a subject, and it automatically becomes an inventive heuristic for the discovery of subject matter."[7] This paper argues that what designers need to improve interface design is a conceptual framework that can spur innovation. We describe that conceptual framework first as "parameters" essential to an interface, and then as a set of "principles" to achieve an effective interface. The parameters and principles were arrived at through inductive study and, we hope, as Winterowd suggests, that they will have the power to not only organize material, but also drive inventive development.

Design principles, as we conceive them, consist of clear rules of thumb that have defined features, similar to the excellent examples found in Edward Tufte's books *The Visual Display of Quantitative Information* and *Visual Explanations*.[8] The principles we propose here must be integrated with the parameters that define an interface. We propose that parameters and principles working together can drive innovation and empower designers or any creative person charged with developing an interface. If the principles are founded appropriately and crafted properly, they should guide the creation of effective interfaces not only today, but facilitate the invention of novel interface approaches in the future.

3 Jef Raskin, "Viewpoint: Intuitive Equals Familiar," *Communications of the ACM* 37:9 (1994): 17–18.

4 Ibid., 18.

5 Catherine Courage and Kathy Baxter, *Understanding Your Users: A Practical Guide to User Requirements* (San Francisco: Morgan Kaufman, 2005).

6 Ibid.

7 W. Ross Winterowd, "Introduction: Some Remarks of Pedagogy" in *Contemporary Rhetoric: A Conceptual Background with Readings,* W. Ross Winterowd, ed. (New York: Harcourt Brace Jovanovich, Inc., 1975), 1–37.

8 Edward Tufte, *Visual Display of Quantitative Information* (Cheshire, CT: Graphics Press, 1983); and Edward Tufte, *Visual Explanations* (Cheshire, CT: Graphics Press, 1997).

Identifying Parameters and Principles through Design Research

Broadly speaking, design research investigates process, user, cultural context, form, and subject matter/content.[9] Design research as an applied research activity focuses on users and content. The design research process used for this project focused on content through the innovative use of content analysis techniques from exegesis: the science of interpretation. Our aim was to analyze interactive content in a thorough way. The premise was that a thorough understanding of the form given to content would lead student investigators to fresh insight into both interface as a form and the audience to which the interface was addressed. From this high level of understanding of interface and audience, investigators sought to define parameters and to describe principles to guide interface design. Our research focused on interaction with content in computational environments. By analyzing one specific type of interface interaction (content), what Kenneth Burke calls an "individuation" in his article "The Nature of Form"[10]. We derived concepts that are abstractions of many individual instances. As Burke argues in his article, the form given to content is revealing of both the author's thinking and the presumed audiences' experience. In Burke's words, "Form … gratifies the needs which it creates." Form is an essential aspect of design.

Interface as a formal tool also is significant in the field of Human Computer Interaction (HCI). In the past, HCI often has focused on interfaces primarily as tools that manage a computer or computer software. However, computer interfaces are no longer experienced only as tools for using computers, but as frameworks for exploring content. Many of the examples in Courage's and Baxter's book on user requirements, a basic HCI issue, are about content-oriented Web sites. Interface as a means to explore content is not just for the Web. One recent product example, the iPod®, is a small, portable computer with an inventive interface. However, the focal point of the iPod is neither the device nor the interface, but the content: music and video (in some models) are the stars. This anecdotal example suggests that product development generally, and HCI interface development in particular, are increasingly involved with developing interfaces for content. Because interaction with content typically is an individual expression of interaction, and because HCI increasingly deals with crafting content-oriented experiences, the principles derived from our study could apply to broader HCI issues.

What follows is a description of the design research process that led to the proposed parameters and principles of an effective content interface.

9 Design Council (www.designcouncil.org.uk).

10 Kenneth Burke, "The Nature of Form" in *Contemporary Rhetoric: A Conceptual Background with Readings,* W. Ross Winterowd, ed. (New York: Harcourt Brace Jovanovich Inc., 1975), 183–198.

The Process of Developing Interface Parameters

Overview

Our research method was inductive. After initially defining what an interface is, student researchers studied the principles of content interpretation, then selected successful content interfaces, and applied the interpretive principles to the study these interfaces. From looking at the structure of many content interfaces, students derived principles that made these interfaces successful. The derived principles then were consolidated and compared to previously published interface guidelines. The process was heuristic, and the goal was to discover design principles that were theoretically based, definitive enough to guide design, and yet timeless enough to guide interface development as technologies and techniques change. We recognize the dangers of starting with individual instances and from individual instances deriving useful general principles. One alternative approach already noted is to identify successful instances and codify these as patterns to follow, such as was done in Duyne, Landay, and Hong's book *The Design of Sites.* The difficulty of the pattern approach is the limit it places on innovation. Despite the authors' claim that "Our patterns direct your energies to solving new problems as opposed to reinventing the wheel," the purpose of a pattern is to provide something to follow, not the invention of something novel. Our purpose was different: describing principles that could spur innovation.

Interface Definition

We began by asking what the essential qualities—the parameters—of an effective interface are. Like many questions, we found the answer depended on context. Cooper and Reimann in their book *About Face 2.0,* state, "… there is no such thing as an objectively good dialogue box—the quality depends on the situation: who the user is and what his background and goals are."[11] In the 1992 version of "Macintosh Human Interface Guidelines" by Apple Computer, widely recognized as pioneering in user interface development, there are thirty-eight index entries for icons, but none for interface.[12] This suggested that interface and icon were nearly synonymous and that, logically, the best interfaces would be those with the best icons; and that those without icons would fail. This is clearly not the case, but suggests the extent to which interfaces had become mired in an existing pattern based on icons and a paradigm of interfaces as tools to manage software. We began to agree with Cooper and Reimann that what made particular patterns such as icons and dialogue boxes meaningful was something more basic than the patterns themselves.

A more general definition of interface was "the interaction between two systems" (*American Heritage Dictionary*). A more recent interface definition from Wikipedia, the online encyclopedia,[13] seemed closer to the point in defining user interface as: "The interface is the functional and sensorial attributes of a system (appliance,

11 Alan Cooper and Robert Reimann, *About Face 2.0: The Essentials of Interaction Design* (Indianapolis IN: Wiley, 2003).

12 Apple Computer, Inc., *Macintosh Human Interface Guidelines* (Boston: Addison-Wesley, 1992).

13 Wikipedia, "User Interface" (http://en.wikipedia.org/wiki/User_Interface). (Acessed: 08/25/2007).

software, vehicle, etc.) that are relevant to its operation by users." However, this definition emphasizes attributes over interaction, suggesting that interface is a thing and not a process. A bit closer to the point, Wikipedia goes on to describe user interface as having two essential components and two general means:

> The user interface is the aggregate of means by which people (the users) interact with a particular machine, device, computer program, or other complex tool (the thing). The user interface provides (the) means of: Input, allowing the users to control the system; (and) Output, allowing the system to inform the users (feedback).

User interface, by this definition, involves both users and "things." The interaction involves both inputs and outputs. For our study focused on content interface, students summarized that any interface has two basic considerations: users and content. A great deal is made in HCI literature about user-centered design and user needs. This suggested that, for users, interaction has a purpose or aim even if that aim is merely one of idle amusement. We therefore defined user interface as the means by which users interact with content to accomplish some goal.

Content Research

Armed with the interface definition above, faculty/student teams initiated a research project to identify the essential features of an effective content interface. We began with an examination of the characteristics of various kinds of content in order to understand how the nature of different content types might impact the design of an interface to that content. The particular inductive method we employed was based on "exegesis," an inductive method used for understanding texts. "Exegesis," a Greek loan word, literally means to lead or draw out (ex—out, hegeisthai—lead or think). Exegesis has been translated as "expound" or "explain," and today has come to mean the principles and methods used to draw the meaning out of texts; primarily religious texts such as the Bible. We drew upon a text-based research approach because we had limited the scope of our work to interaction with content rather than interaction more generally.

Respect for context and content type are the key principles of exegesis. Following these principles, students selected, analyzed, and compared the linguistic features of three different content types, ranging on a continuum from poetic to scientific proposed by noted author C. S. Lewis. The specific content types: poem, newspaper editorial (from an edition of the *New York Times*) and scientific report (from the *New England Journal of Medicine*), were intended to be representative of the full spectrum of content types.

Syntactical diagrams were created for each content type as a technique to analyze the structure and meaning of the content.[14] Word frequency, part of speech, and meaning were analyzed and compared. A typical finding was that scientific articles contain words with a high volume of very precise, often specialized meanings. On the other hand, poems use common words, often with atypical or unexpected metaphorical meaning: the words are not always used literally. Syntactical structures of each content type were similarly analyzed and compared. A typical finding was that poems do not speak in complete sentences, that editorials build arguments; and that scientific papers use rigid problem/solution structures with no personal references. The linguistic features were used to theorize authorial intention in writing the content and, by implication, the intended audience. Teams reasoned that the authors of scientific articles strive for precision in order to accommodate a small but specialized audience, while poets strive to create a general impression with a broad audience. Determining authorial intent through linguistic analysis is unusual in design research, but is integral to hermeneutics and exegesis; and the processes and techniques for it are well established.[15]

The result of this research was to define a continuum of "content types" bounded by two extremes:

> *A. Content Type Continuum: from the Scientific to the Poetic.*
> **Scientific**
> Scientific information is explicit in the rules of interaction between user and content. It is clear, direct, and adheres to established content hierarchies and structures. It is accessible and often is thought of as part of a larger community of information that shares a common language and purpose. Scientific information usually is cross-referenced with similar and contrasting data, and typically is intended to share information and inform its audience without bias or emotion.
>
> **Poetic**
> Poetic information, in contrast, asks to be experienced. At a more practical level, poetic information may not adhere to the established content structure or hierarchy in favor of artistic or personal interpretation. Instead, it crosses boundaries and requires participation on multiple levels between user and content. Poetic information is categorical, conceptual, emotional, and usually includes sensory value.

The features of these of interactive content types were analyzed and compared to deduce their strategies for delivering content. In a departure from exegetical practice, strategies, rather than authors, were described since current media seldom has a single identifiable

14 Walter Kaiser, Jr., "Toward an Exegetical Theology" in *Web Style Guide: Basic Principles for Creating Web Sites,* Patrick Lynch and Sarah Horton, eds. (Grand Rapids, MI: Baker, 1999).

15 Ibid.

author. Four broad content delivery strategies were loosely defined: a "reference strategy" serving discrete bits of information to a specific inquiry; an "educational strategy" offering large quantities of information to teach about a more general topic; an "inspiration strategy" to motivate or inspire an audience and lead self-discovery; and an "entertainment strategy" to amuse or divert the attention of a generalized audience. Examples of each strategy were identified and their content analyzed. A profile of the supposed user was created. In some cases, the strategies themselves were given personae akin to the user profiles / scenarios employed in the development of interfaces.[16] Over time, these initial strategic descriptions have evolved into a continuum of four Content Delivery Strategies:

B. Content Delivery Strategies/Roles

Reference—The Librarian

A content delivery strategy designed to serve discrete bits of information to users. Reference delivery takes the persona of a librarian. Reference delivery is believable, and is connected to a much larger community of information. The reference source is driven to provide as much information as possible in as few steps as possible.

Educational—The Instructor

A content strategy designed to instruct, often in a step-by-step fashion. Unsurprisingly, educational delivery of content takes on the persona of a teacher. An educational or teaching delivery still maintains a high degree of believability and trust, but is more likely to be sequential and increase user knowledge through a series of learning or building steps than the cross-referencing librarian persona. The teacher, like the librarian, is driven to educate its audience.

Inspiration—The Speaker

A content strategy designed to motivate or inspire. Inspirational delivery takes on the persona of a motivational speaker. Often, the inspirational source has a more personal connection to the audience through calls to action and directives. The inspirational source derives its trust through emotional response and personal connection rather than through factual data.

Entertainment—The Actor

Finally, an entertainment delivery strategy is designed to amuse. It may take on the persona of an actor, and is geared to draw a browser audience. Again, it establishes a more direct connection with the audience and requires direct participation from the user. Entertainment sources are the

16 Cooper and Reimann, *About Face 2.0: The Essentials of Interaction Design.*

most open to interpretation, and may even require audience participation in establishing the content. In this scenario, the user is given a more authorial role than in the reference and educational strategies.

Student teams continued to follow an inductive process through personal interaction with various Web and interactive media experiences, in order to define significant parameters of the user. Although it is difficult to select only one means of describing the user, we focused on user intention as opposed to "user need," because every user action is not driven by need: one does not necessarily need to chat online with a friend. User intention also suggests the variability of a single user's approach to an interface from session to session, or even from moment to moment. Teams inferred the users' intentions that each interactive content strategy was designed to meet. Using "reverse engineering," students analyzed the content information structure and the interactive approach of interactive media in order to infer user intention. Students concluded that visual form is, in many cases, an indicator of user intention the media was designed to meet: data-oriented sites showed less concern on aesthetics, entertainment-oriented media more. Student reports raised questions such as: "Does the look of a reference site really matter, if all the user is going to do is go in, grab something, and head back out?" and "… www.m-w.com serves as a superb reference site, but probably is the worst looking site out there."

Like "content types," user intentions were described as a continuum bounded by two extremes:

C. User Intention Continuum: from the Hunter to the Browser
Max Bruinsma has said, "The Web encourages a predator's glance, processing a vast amount of fleeting information fast, before focusing on a target."[17] How a user chooses to interact with an interface often is determined by his or her purpose or intentions in accessing the content. In order to address this, we have broken user intention into two extremes of scale, that of the "browser" and the "hunter."

The Hunter
The hunter is focused, precise and often destination-driven. The hunter values the speed and efficiency of an interface, and rarely deviates from its initial content direction to discover a new path. Also, a hunter's final content destination is determined prior to the search while, at least initially, the browser may have no direction at all.

17 Max Bruinsma, *Deep Sites: Intelligent Innovation in Contemporary Web Design* (New York: Thames and Hudson, 2003).

The Browser

The browser is intent on the journey and, in many cases, may not have a final content destination in mind. The browser is less focused and driven in the search for content, and more likely to be open to new experiences. As an audience, the browser perhaps is more likely to notice and even be driven by the design of an interface.

A key difference between the users is their scanning behavior. The hunter may scan large quantities of information quickly in order to find a predetermined target information or content. The browser may scan that same information looking for a general topic, new pathways, or even a diversion. Quite simply, the hunter is driven by need while the browser is directed by personal interests or curiosity.

All content has an inherent structure. Content's inherent structure may be modified to fit a specific strategy, giving it a "strategic structure." This strategic structure takes the form of an interface in interactive content. An interface may be classified by the *structure* of the final content delivery. Four common interface types[18] were described to students: linear, hierarchy, matrix, and web. The assignment was to evaluate each of these in relation to the content types, content strategies, and user intentions; and to define how different user intentions and content types might be served by the interface structures. We determined that, based on inherent and strategic content considerations, efficient and appropriate interfaces can be created along four structural themes: linear, hierarchical, matrix, and web.

18 Patrick Lynch and Sarah Horton, *Web Style Guide: Basic Principles for Creating Web Sites* (New Haven, CT: Yale University Press, 1999).

Figure 1
Matrix of content delivery roles.

	REFERENCE	**EDUCATIONAL**	**MOTIVATIONAL**	**ENTERTAINMENT**
VOICE	content specific, clear and to the point, direct	clear. specific. uses accessible language in effort to inform audience	stimulating. intent is to inspire users. accessible language	vague and open to interpretation
AUTHORSHIP	values expert opinions	trustworthy, researchable authors	uses emotions to inspire trust rather than authorship	open, may require content participation from user to establish meaning
MOTIVATION	provide accurate data quickly. inform.	inform and educate	inspire and emotional connect. to stimulate	inspire and stimulate the audience. diversion.
CONTENT STRUCTURE	established content structure. cross-referencing and linking. most likely to be hierarchy	established content structure. accessible to large audience	less content structure, more open to interpretation	vague, open to interpretation
SCALE	links to much larger body of similar data	may be part of a larger community of data. can also be singular.	more often, a single site that may contain links to similar information	self contained and most likely to be linear in structure.

D. Content Structures

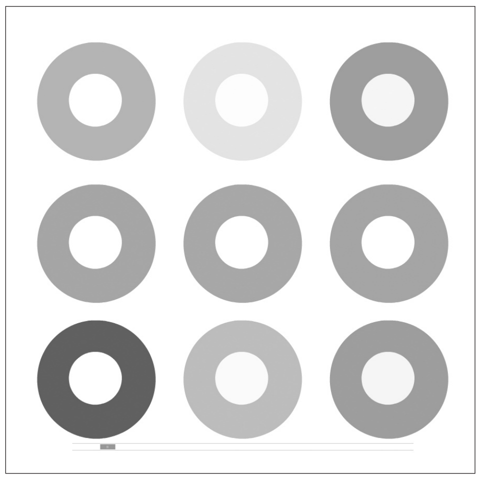
Linear

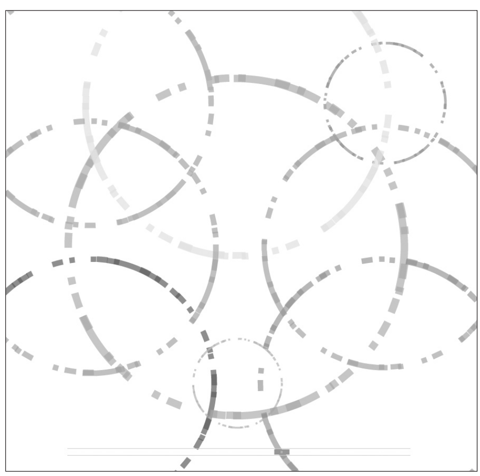
A linear interface is one that is fixed sequentially. Scientific content, having a fixed and sequential structure, is delivered step-by-step, with one additional piece of information following each successive selection. Instructions given following a teaching strategy would be well suited to a linear structure.

A linear interface is built with the following guidelines in mind:

1 Each successive step of a linear interface builds on the previous step.
2 The designer has the most control over the pace and amount of content a user can access.

Figures 2 and 3
Student example, Phillip Harvey.
Student exercise exploring linear interaction. The content progressed from a grid of nine static circles to a dynamic composition of line segments through the use of a segmented scrollbar.





Hierarchy or Tree Structure

The tree diagram or hierarchy is an interface that expands topically. In a hierarchy, several options may follow each selection. A hierarchy is suitable for content with a parent/child structure, and often is associated with a reference strategy.

A hierarchy interface is built with the following guidelines in mind:

1 A hierarchy, or tree diagram, is an interface that expands topically from broader topics to more specific topics in a branching fashion.

2 Several options follow each selection, depending on content structure.

3 Hierarchy interfaces should be efficient and allow users to access their desired content quickly and with a minimum of additional steps.

4 In a hierarchy, the content and user share control. In *The Language of New Media,* Lev Manovich states that "the user of a branching interactive program becomes its coauthor. By choosing a unique path through the elements of a work, she supposedly creates a new work." But it also is possible to see this process in a different way. If a complete work is the sum of all possible paths through its elements, then a user following a particular path accesses only part of the whole. In other words, the user is activating only a part of the total work that already exists.[19]

5 In a hierarchy, an independent value system determines the content structure (size, value, like content), and allows a user to access specific information quickly with a minimum of searching.

19 Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT Press, 2002), 128.

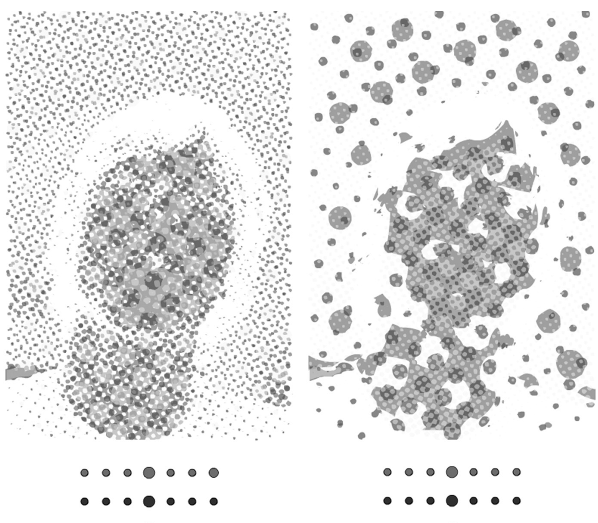
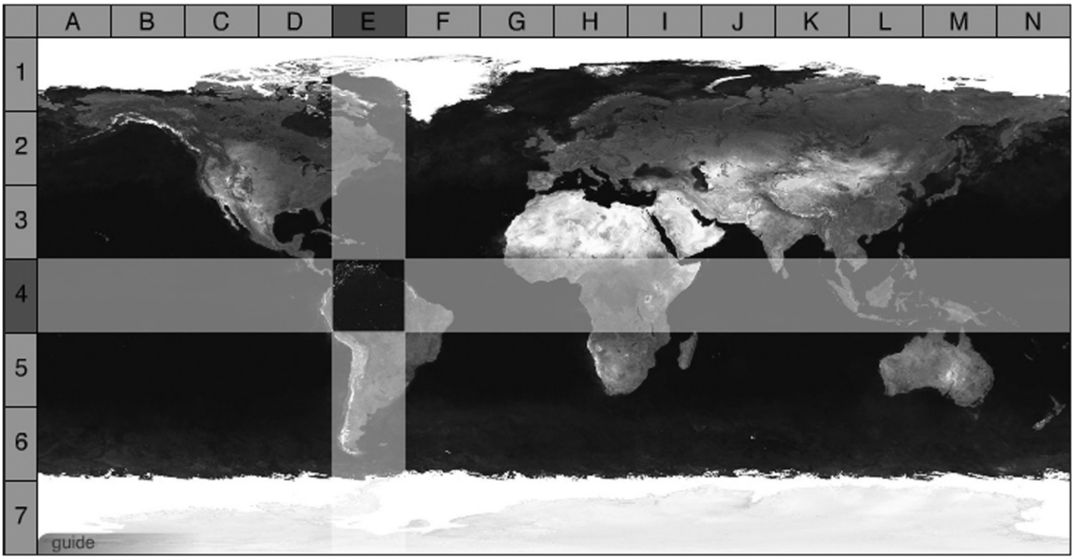


Figure 4
Student example, Ben Prince.
Student exercise exploring hierarchy.
Users controlled the content appearance through color, size, and resolution.



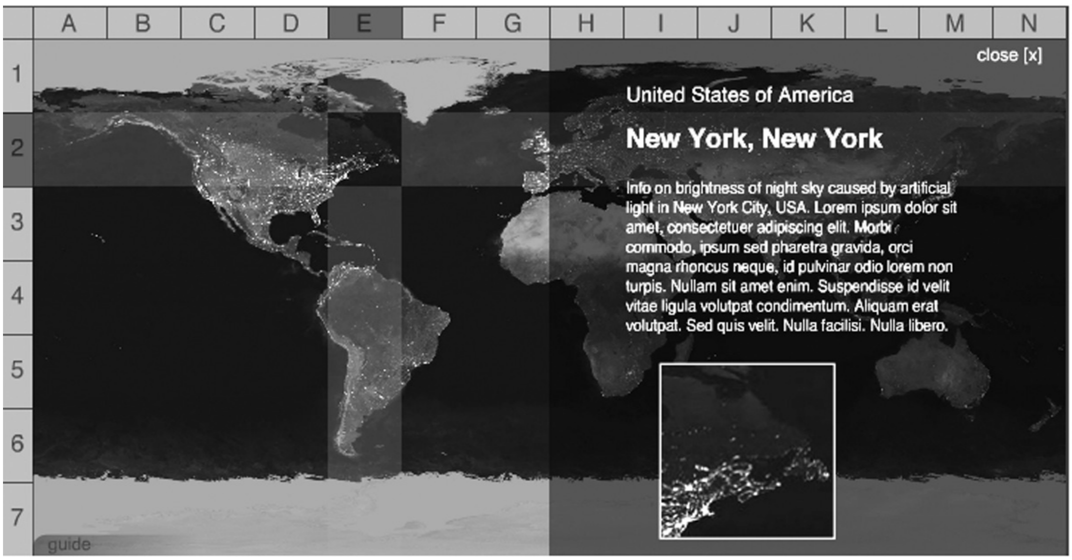


Figure 5
Student example, Ryan Devenish.
Student exercise exploring the matrix structure. Content about major cities was revealed through its placement on a grid.

Matrix

A matrix interface is one that simultaneously presents multiple relational options, usually organized by categories. A matrix is well suited to content with multiple related categories following a reference strategy.

1 A matrix interface presents multiple relational options simultaneously.
2 A matrix interface should be extremely efficient and allow a user to access a large set of data simultaneously in order to make comparisons and judgments about that data.

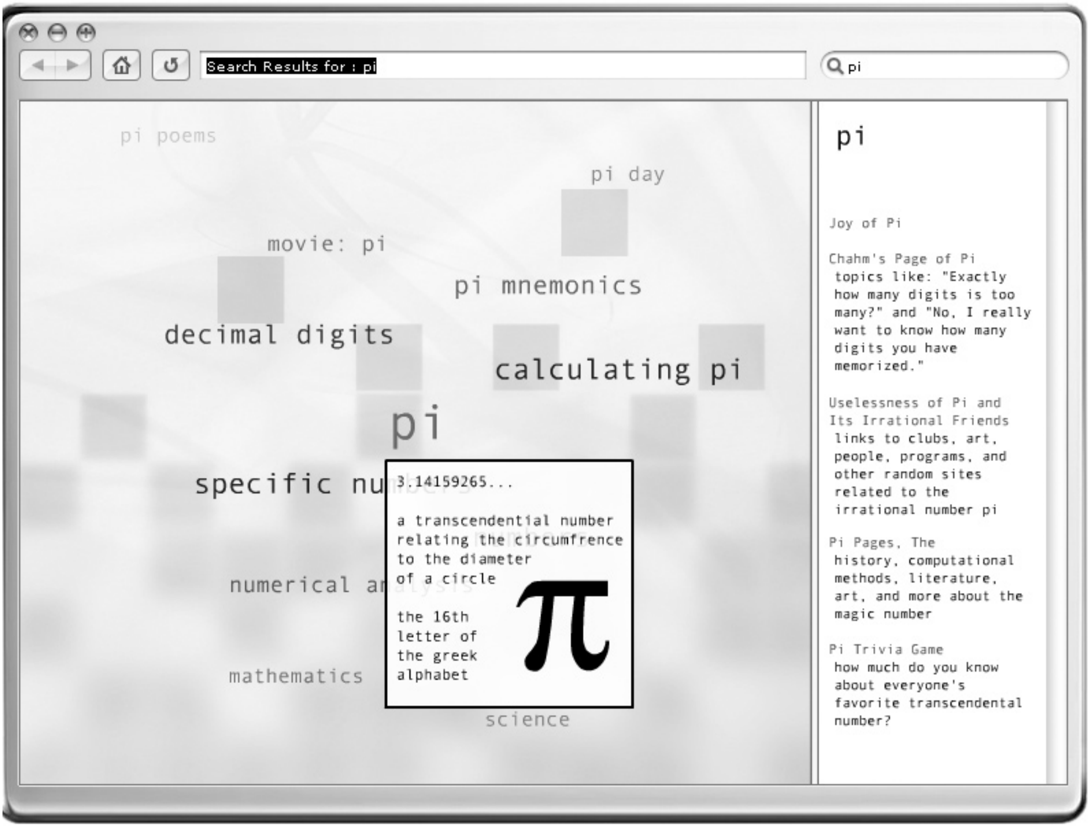


Figure 6
Student example, Tim King. Search results were place within a matrix based on how scientific or poetic the content was and how closely it related to the search query.

Web
A web is an interface freely associated cluster of undifferentiated items. It is useful for unstructured content following an inspirational or entertainment strategy.

The Process of Developing Interface Design Principles
Using the foregoing understanding of content type, content strategy, user intention, and content structure as a basis, teams of three to five students examined a variety of what they deemed to be successful Web site interfaces. Teams established a set of criteria for each interface that defined why these interface designs were successful. Individual team reports were presented to the full group. The group analyzed, compared, and synthesized their reports in an affinity diagram that resulted in the first draft of the design principles presented in this paper. The stated focus was to develop design criteria that a designer could apply. Emphasis was placed on not defining outcomes such as "easy-to-use," and on being specific as opposed to vague such as "intuitive." Questions such as "What makes this intuitive?" were repeatedly addressed to each principle. Once the principles were identified, they then were compared to published lists of principles in sources such as Patrick Lynch[20] and Apple, then consolidated further. An example of such a comparative list follows:

20 Lynch and Horton, *Web Style Guide: Basic Principles for Creating Web Sites.*

Table 1
Title goes here

Apple	Early / Zender Compared	Lynch
Metaphors	**Metaphor**	Clear Icons
Direct Manipulation	n/a	
See-and-Point	**Proximity: Concept Space**	
WYSIWYG	**Proximity: Physical Space**	Fewest Possible Steps
User Control	User Control	
Feedback and Dialogue	**Feedback**	Feedback
Forgiveness	**Reverse**	Return Easily / Go Back
Perceived Stability	**Landmarks**	Sense of Where You Are / Context
Aesthetic Integrity	**Content & Form**	Design Integrity
Modlessness	**(Feedback)**	
Knowledge of Audience	**[USER PARAMETERS]**	Disabled Users
Accessibility	**[USER PARAMETERS]**	Overview
	Subject Clear at Start	Screens
		No Dead Ends
		Bandwidth
		Simplicity and ...
	Consistent Logic	Consistency
	Conventions	Legacy (Graceful Degradation)

Early / Zender Original List
~~User Control~~
~~**Start**~~
~~**Reverse**~~
~~**Consistent Logic**~~
~~**Conventions**~~
~~**Feedback**~~
~~**Landmarks**~~
Efficiency
Customization
~~**Proximity**~~
~~**Concept & Physical**~~
Help
Content:
~~**Subject Clear at Start**~~
Interface in Content
Interface & Visualization
~~**Content & Form**~~
~~**Metaphor**~~

For further validation, this list was compared to a similar consolidated list "General Principles for HCI" in Dumas's chapter on basing design on expertise in human-computer interaction:[21]

Giving the user control
Striving for consistency
Smoothing human-computer interactions with feedback
Supporting the user's limited memory.

Following comparison and review, the various student lists were condensed into the following set of Interface Design Principles.

Interface Design Principles

A. Obvious Start: Design an Obvious Starting Point

A user must know how to start interaction with the content. In perceptual terms, "obvious" might be defined as visual form that is pre-attentively processed.[22] Pre-attentive features are proven to "pop-out" and include: size, value, hue, orientation, shape, enclosure, blurriness, and movement. Arguably, movement is the most basic pre-attentive feature, capable of attracting attention even in the periphery of our vision. Pre-attentive features should be applied using an "odd man out" principle, where the uncommon pre-attentive feature is the one that immediately stands out from its peers. For example, one red word in a paragraph will stand out. A continuum for this principle might be defined as from blatant to subtle.

A starting point is needed because every encounter with a new interface involves a learning process. Cognitively, we learn through finding patterns among details. In order to learn the interface, the user must know where to begin the learning process. This may seem obvious, yet often is overlooked. In the late 1980s, IBM, then still actively engaged in making typewriters, did an extensive redesign of their typewriter line basing the product revisions on extensive user research. One of the key findings was that the most fundamental problem with using the typewriters was how to turn the machine on: the user needed an obvious start button. The equivalent in architecture is to make the position and function of the door of a building obvious.

B. Clear Reverse: Design an Obvious Exit or Stop

The user must know how to reverse any action, including how to exit or end the session. Again, "obvious" might be defined as what is pre-attentively processed but, in the case of a reversal, "obvious" only is needed occasionally. Therefore, the reversal should become obvious "on demand," and should not necessarily pop-out continuously. The reversal should be omnipresent and clear but subtle. Subtle might be defined following Edward Tufte's concept of smallest effective difference.[23] The result would be present but unobtrusive. "Exit" may be defined as anything that stops or interrupts the current state. A familiar example of a reversal/exit is the "close window" feature common in both Mac OS and Windows operating systems.

"Reversal" is not simply the opposite of start. And exit is more than just the end. Knowing an exit route may provide the sense of confidence necessary to sustain an interactive session. Apple's "Guidelines" call this principle "forgiveness" and state that "Forgiveness means that actions on the computer generally are reversible. People need to feel they can try things without damaging the system."

21 Joseph Dumas and Janice Redish, *A Practical Guide to Usability Testing* (Norwood, NJ: Ablex, 1993). Elsevier, 2004).

C. Consistent Logic: Design an Internally Consistent Logic for Content, Actions, and Effects

Note: the most important consistency is consistency with user expectations.

Within an interface, a user must be able to quickly identify a logical, rational pattern of relationships between user actions and effects. By "internally," we mean within the world defined by the interface and its content. Design patterns should be consistent within the world the interface develops. To reinforce the pattern, a user must be able to depend on an acceptable level of consistency. For example, if buttons change form on hover, they should respond in a similar way or a logical extension of that way for a similar action. Consistency does not mean monotony. It is possible to design a rational evolution of relationships between user actions and effects throughout the interface experience. The actions and effects might change in logical ways as content changes. For example, as content becomes more detailed, user feedback sounds might become softer or higher in pitch. Uniformity is not the answer: logical progression and development that keeps interaction consistent with and reflective of content is. A user should find a logical consistency of all aspects of interaction, from visual form to motion, and the connections of these to content types. A continuum for this principle might be defined as from consistent to erratic.

This may be the most comprehensive principle for good interface design. It is based on human logic and cognition. When patterns are consistently and rationally connected to actions and content, users with average cognitive abilities will recognize the patterns and their meanings. Internal consistency is important because each interface creates a world that is distinct, though not isolated, from its immediate context (see the next principle for respecting conventions). Consistency reinforces learning and keeps the learning curve brief. Comprehensiveness builds a sense of reliability and keeps users from wondering whether different forms, words, situations, and actions mean the same thing.

D. Observe Conventions: Identify and Consider the Impact of Familiar Interface Conventions

Identify and respect a user's familiar interface language of words, phrases, images, and conventions. An interface does not need to obey all interface conventions familiar to a user, but it should violate those conventions with care. Respect might be defined as only violating a convention only when such violation gives a particular advantage or avoids a particular problem. Existing conventions can be built upon, extended, or even played with as appropriate for user and content parameters. A continuum for this principle might be defined as from observe to ignore conventions.

22 Colin Ware, *Information Visualization* (San Francisco: Morgan Kaufman/ Elsevier, 2004).

23 Edward Tufte, *Visual Explanations*, 73.

Users do not come to an interface as a blank slate, but rather with a host of previous experiences and expectations. Social and cultural experiences are preexisting conditions deserving respect.

E. Feedback: Design Tangible Responses to Apt User Actions
Users should receive feedback as they do tasks. Make the feedback as immediate as possible to the action in time and space. "Tangible" can be defined as feedback that is noticeable. Again, Tufte's concept of smallest effective difference might be applied here, making the effect of actions as minimal as effectiveness permits.[24] Keep the feedback proportional to action's importance. Feedback should be logically consistent and in alignment with content as noted previously. A continuum for this principle might be defined as from immediate and direct to delayed and disconnected.

Immediate feedback is necessary to keep users informed that their actions are having an effect. Apt feedback can be a form of reward for the user.

F. Landmarks: Design Landmarks as a Reference for Context
Users should have available information suggesting their location in the conceptual space of the interface. Design noticeable reference points, features, or landmarks that the user can identify. Some of these should be available at any time. These may be the equivalent of mile markers the user has passed, indicating progress; or behave as highway signs showing where they might go. A continuum for this principle might be defined as from clear or many to obscure or few.

Landmarks build upon users' ability to build a mental model of their experience. Landmarks are significant in the related field of "wayfinding" as it relates to spatial navigation. They also are significant in procedural knowledge as it relates to the logical or non-spatial mapping of information. Landmarks support the user's cognitive map, and help users identify where they are and where they can go in relation to the other aspects of the content.

G. Proximity: Design Interface Elements in Consistent Proximity to Their Content Objects and to Each Other
A user should not have to traverse great physical, conceptual, or time spaces to perform similar actions or access related content. There are at least three kinds of proximity: space, time, and concept. Good proximity in space builds on users' location memory by associating content and interface in a consistent or logical evolution of X Y Z space. Good proximity in time means content is available when the user wants it. Proximity in concept space means related items are grouped. An example of conceptual space is Apple's "see and point" menu system which groups related items into conceptual

menus. Cluster similar items spatially as well as conceptually. Design consistency in the spatial location of related objects. A continuum for this principle might be defined as from close to distant. Proximity is important because visual working memory has a spatial component that remembers the positions of up to three to five specific objects.[25] Proximity advantages this innate memory.

H. Adaptation: Design an Interface That Adapts or Is Adapted to Use

Allow users to tailor the interface to frequent actions. Design interfaces that identify and adapt to user segments. Envision systems in which the interface adapts itself to user needs or to patterns of interaction. For example, an interface could be envisioned that over time automatically minimizes or even eliminates infrequently used features or menu items. A continuum for this principle might be defined as from adaptive to inflexible.

Customization advantages different user intentions, and fits them to diverse content types even within one application. It acknowledges that users can be novices or experts with the interface, the content, or both.

I. Help: As Necessary, Provide a Readily Accessible Overall Mechanism for Assistance

Design a support source of last resort. Make it available, but keep it subtle. An example is the help feature in many software applications. However, do not use a help menu as a crutch for poor navigation. Recognize where complexity demands it, and provide help that is easy to search and linear in form when instructions are involved. A continuum for this principle might be defined as from available to distant.

J. Interface Is Content: Design Interface Elements That Minimize Interface and Maximize Content

A user utilizes an interface to get access to content. Therefore, content is paramount. The interface is part of the content, not merely a means to access content. Design the interface so that interaction is as direct with content as possible. Avoid interfaces that come between the content and the user. Wherever possible, make the interface part of the content, and not just an unrelated control. The interface serves the content, not the other way around. A continuum for this principle might be defined as from integrated to separated.

Every extra unit of information in a dialogue competes with other content. Interface elements, when divorced from content, can become noise that obscures the purpose of the interface.

24 Ibid.

General Design Principles

The following principles constitute good communication design practice and, as such, should be included in interface design practice, but are not specific to interface design. Every interface, by definition, engages a user with some content. It is logical for the interface to reflect the nature of the content in every possible aspect. The interface type should match the content type and user intention. For example, step-by-step instructional content is best presented with some variant of the linear interface.

A. Subject Matter: Make Subject Matter Obvious from the Start

A user should gain immediate understanding of the subject matter related to the interface. Design the interface so that in every aspect it expresses the content and content type.

Content types differ in nature and structure, and thus require different interfaces. Poetic content, ambiguous by nature, will not submit itself to hierarchical categories and information trees.

B. Interface Visualization: Use Visual Form Apt to the Content to Embody the Interface

Presenting information visually engages the user's ability to sense and feel; compacting much information into a quick, perceptual encounter. The power of computers to collect, store, and manipulate numbers far surpasses human capacity to understand that same data. As a result, the visualization of large quantities of information takes on great significance, transforming incomprehensible data into understanding.[26]

Humans have remarkable perceptual abilities to scan, recognize, and recall images, as well as to rapidly detect meaning in patterns and changes in size, shape, color, movement, and texture. Text requires more cognitive effort to understand content, because the relationship between form and meaning is somewhat arbitrary.

C. Content + Form: Design Apt Visual Form Based on Content

A user must be engaged by the formal visual qualities of the interface. Design an interface that is visually engaging, or aesthetically successful; which are essentially two ways of saying the same thing. The most apt visual form is one that reflects the nature of the content in a stimulating way. An interface that fails to engage and keep a user's attention has failed by definition: the user has disengaged and no longer interfaces with the object or content.

Museums can testify that people everywhere and at all times have desired visually engaging objects as cultural artifacts. Building a visually engaging interface applies this proven principle in order to engage and hold the interest of a user.

25 Colin Ware, *Information Visualization.*

D. Metaphor: Use Metaphors Where Content Is New, Obscure, or a Narrative-Based *Visual Metaphor*

Metaphors trigger memories and build associations. Use them where helpful, particularly when introducing new or obscure concepts.

The following is the essence of *Working with Interface Metaphors* by Thomas D. Ericsson:

> Metaphor is an effective tool in interface design in that it engages users more fully, allowing them the ability to use previous knowledge and experience to better understand current unknown experiences. A metaphor is an invisible web of terms and associations that underlies the way we speak and think about a concept. Metaphors function as natural models, allowing us to take our knowledge of familiar, concrete objects and experiences and use it to give structure to more abstract concepts."[27]

Integrating Interface Parameters with Interface Principles

To properly guide the design of an interface, we believe the principles for design proposed above in Section Two must be integrated with the parameters defining interface outlined previously in Section One. Principles in isolation do not provide sufficient guidance to inform design decisions. The principle "Obvious Start" comes from, and is mediated by, user intentions interacting with content type, delivery strategy, and content interface structure. For example, the obviousness of the entrance of an interface for a browsing user experiencing poetic content with an entertainment strategy composed in a web structure will be different from a hunter of scientific content.

Having defined a user interface as:
the means by which users interact with content for a purpose,

and having defined the Parameters that govern an effective interface as:
Content Type: Scientific – Poetic
Content Delivery: Reference - *Educational* - *Inspiration – Entertainment*
User Intention: Hunter – Browser
Interface Type: Linear – Hierarchy – Matrix – Web

and having established a workable list of best Design Principles:
Obvious Start:
Clear Reverse:
Consistent Logic:
Observe Conventions:
Feedback:

26 Marc Green, *Toward a Perceptual Science of Multidimensional Data Visualization, Bertin and Beyond* (Toronto: ERGO/GERO, 1998), 11.

Landmarks:
Proximity:
Adaptation:
Interface Is Content:
Help:

We can integrate the parameters and principles to establish a parameter | principle matrix that can guide design decisions. An example is described and graphically illustrated below.

A designer is designing an interface for poetic content: a movie promotion. The presentation strategy is a speaker because the film has documentary qualities, while the user intention is anticipated to be a hunter intent on finding specific historic references touched upon in the film. The content structure selected to support these conflicting needs is a matrix. To fulfill the principle of providing an obvious start to meet the above parameters, the designer might choose a start toward the subtle end of an obvious to subtle continuum. To create a subtle but effective start, the designer might select a fairly muted color on a bright-to-muted continuum, a small size on a large-to-small continuum, but an obvious upper left corner location, following Western reading direction conventions, on an obvious-to- obscure location continuum. The result of these decisions is illustrated on the following chart:

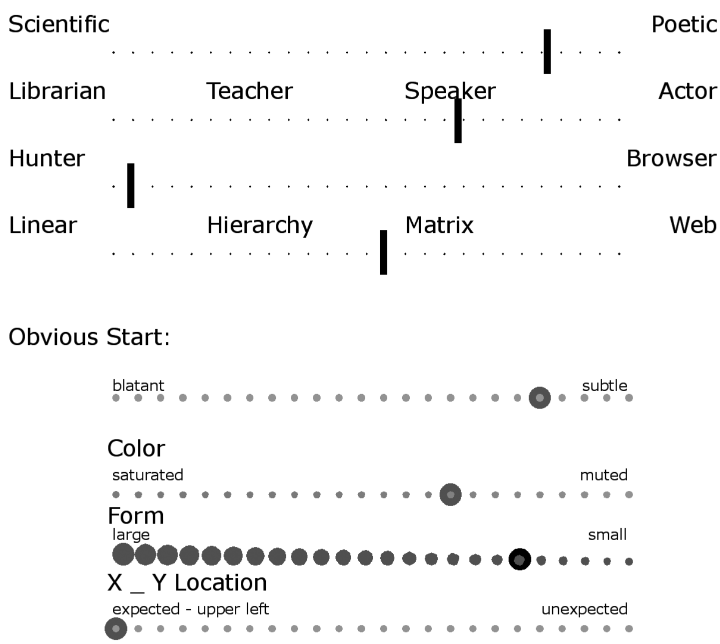


Figure 6
Student example, Tim King. Search results were place within a matrix based on how scientific or poetic the content was and how closely it related to the search query.

27 Thomas Ericsson, *Working with Interface Metaphors* (Boston: Addison-Wesley, 2001), 66.

Note that the decisions related to "obvious start" align roughly with the interface parameters above them, causing each design decision to be taken in reference to the specific interface parameters being addressed. While this process could be followed with each interface principle in turn: clear reverse, consistent logic, observe conventions, and so forth; in practice, consideration of a just a few principles generally leads to a design theme or system that encompasses the other principles. The process is not linear, but iterative and global, consistent with the principle of consistent logic. We believe this approach has great flexibility while accounting for all the relevant factors. The principles proposed are actionable, and have the potential to be measurable. While guidance is clearly prescribed and is based on the parameters of an interface, the means to accomplish such an interface are left completely open, inviting invention and innovation. Novel combinations can be envisioned and may even be encouraged. Recipes for making Web site maps are replaced by guidance in establishing landmarks and contexts for a particular user intention and content type. Gone are vague descriptions of end states; replaced by a creativity-expanding matrix of distinct possibilities aimed toward a target experience.

Need for Further Study

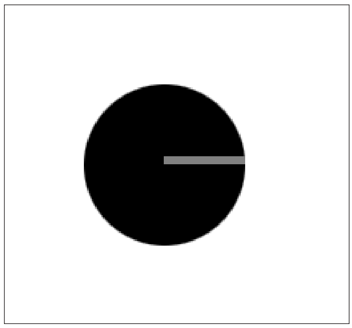
We have applied these design principles in a variety of classroom interface design projects clustered around the theme of content exploration and wayfinding in museum settings. The projects have produced interface prototypes. In applying these principles in the design of simplified and incomplete interface models, students have been able to explore ideas, elaborate requirements, refine specifications, and test functionality. These principles have given the designers a method to visualize, evaluate, learn, and improve design function.

Even so, more work needs to be done.

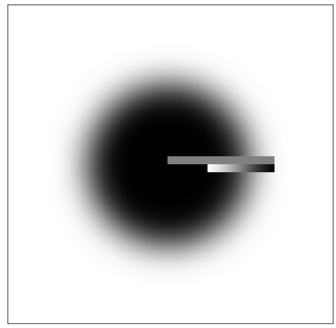
Each of the design principles proposed in this paper should be defined so that its parameters are measurable. Unfortunately ours are not. Design theory and practice are woefully inadequate in defining visual form in quantifiable ways. If parameters are not measurable, they are not really attainable: they are just nice advice. The field of design is ripe with good advice, and while we are happy to add our voice to the chorus, that is not ultimately our aim. We hope to see research in design expand to include the features and functions of visual form so that design principles that relate to visual form, such as those proposed here, can be defined, measured, tested, and refined.

Through research in and out of the classroom, we have discovered that such definitions are possible. For example, the pre-attentive visual feature of blurriness, noted in the "Start" Principle, recently was defined in a student research project as the ratio of gray to solid pixels. Further, the point at which the ratio became effectively pre-attentive, the point at which it popped out, was established. Through this study, it was determined that dark values project blurriness with less real physical blur than light values. Pushed further, a ratio of blurriness to background value might be developed quantifying the degree to which different amounts of blurriness pop out from their surroundings. These ratios could be applied to the "Start" and "Exit" principles, tested, and evaluated. Unfortunately, there are nearly a dozen pre-attentive features. This study barely explored one, and that one in isolation from the others. More studies such as this are needed to define effectiveness of visual form, and how it might be used to quantify visual attributes in interface displays.

Figures 7 and 8
Student example, Chrissie Talkington.
Initial research for the design principles noted in this paper. Blurriness example.



Blur Radius:
12 pixels black = Blur Ratio 1 : 0



Blur Radius:
6 pixels black, 12 pixels gray =
Blur Ratio 1 : 2

Summary

We believe it is clear that interface parameters and design principles can be combined in a way that to supports a design practice. We also believe that an integrated approach combining users, content, and form is comprehensive enough at a high level to guide the design of novel and effective interfaces. As a result of this study, it also is clear that more precisely defined parameters for visual form are needed in order to apply design principles in measurable ways. Without more detailed knowledge of the effects of the execution of visual form, the principles proposed above can only be applied intuitively. We believe that the next steps are to conduct research in visual form, and apply it to the proposed principles to define them in more measurable ways. Through continued research, we would like to convert intuition into significant knowledge so that designers can grow to make the kind of contribution to human understanding that we believe we are capable of making.