Collaborative Design and the Science of Design

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INTRODUCTION

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

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

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

TWO STUDIES OF COLLABORATIVE DESIGN

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

Collaborative Design of a Museum Exhibition

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

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

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

I used ethnographic methods such as participant-observation and interviewing and also used documentary

analysis. Data was collected at the Natural History Museum for over a year between December 2001 and March 2003. I spent well over two hundred hours in the field with members of the exhibition design team and collected over a thousand pages of field notes, documents, and photographs.

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

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

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

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

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

Collaborative Design of Cyberinfrastructure

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

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

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

While it will be years before FBIRN will be able to fulfill its long term goal of having a large data repository where

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

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

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

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

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

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

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

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

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

We have found the metaphor of infrastructure useful here precisely because of the way it allows us to talk about the human structures relationally in just the same way as we might approach technological infrastructures in CSCW

terms. We have argued that a view on human infrastructure might equally serve to problematize the teams and networks by which distributed collaboration is frequently, and perhaps all too easily, explained.

DISCUSSION

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

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

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

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