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COLLABORATIVE DESIGN: A TAXONOMY OF ARTIFACTS AND PRACTICES USED TO DESIGN A MUSEUM EXHIBITION

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ABSTRACT
Design students would benefit from a curriculum that cultivates an understanding of collaborative design as being simultaneously and essentially social and artifactual. This papers reviews the literature and describes research that used ethnographic methods and documentary analysis to study the artifacts and surrounding practices of an interdisciplinary team of museum employees as they designed a large museum exhibition. Building from the concepts of boundary objects (Star and Griesemer 1989) and of communities of practice (Wenger 1998), this paper describes artifacts that negotiate boundaries between communities of practice and facilitate collaborative design. Finally, implications for design education are discussed.

Keywords: Design, Collaborative Work, Artifacts, Documents, Exhibition, Ethnography

1 INTRODUCTION

Design educators would do well to acquaint students with studies of collaborative design work. Complex design work frequently requires the collaboration of designers who have very different skills, values, and training. Cultivating a sophisticated understanding of collaborative design as a process of learning and innovation in which the creation and negotiation of social practices and intermediary artifacts are a necessary part will help prepare students for professional life.

2 DESIGN AS A SOCIAL AND ARTIFACTUAL PROCESS

There are several different paradigms for the act of designing. Common paradigms include design as an artistic creative process, design as information processing, design as a cognitive process, and design as communication. These paradigms have all yielded useful information about different aspects of design. (I use the word *design* in this paper in the verb sense of designing, or more specifically, design practice.) A fifth paradigm that weaves together threads from the four listed above captures more completely the complexity of design practice. This work tends to be interdisciplinary in nature, and finds design to be both socially-situated and dependent upon on a variety of artifacts. I call this paradigm *design as a social and artifactual process*.

2.1 Ethnographic Studies of Design Teams at Work

Many ethnographic studies of designers at work [1, 2, 3, 4] have found design to be a social activity that requires the production and use of intermediary artifacts in order to produce the ultimate artifact--the finished design. The social and artifactual nature of

design, although not referred to as such, is remarked upon in each of the studies described below.

2.1.1 Knitwear Design, Mental Models, and Culture

Eckert [4] studied knitwear design teams comprised of designers and technicians. Typically the design teams were comprised of members who had different backgrounds and expertise. Eckert noted that knitwear designers and technicians usually communicated through technical sketches. But because the two groups had different mental models underlying the creation and interpretation of sketches, they had difficulty communicating.

The shared culture of the knitwear designers and their background in fashion design gave them a particular understanding of specific artifacts. Because technicians did not share this culture, communicating through technical sketches was difficult. Lacking a common notation system, the social context in which artifacts are created and used cannot be separated from the artifacts without difficulty.

2.1.2 Design Constructed Through the Interaction of Multiple Actors

Two case studies of architects and engineers design work found that design is constructed through the interactions of multiple actors, and that artifacts have a key function in the organization of work [2].

A wide range of artifacts contributed to the design process including pencil and paper, drawing tools, filing cabinets, spreadsheets, telephone, fax, white board, and prototypes.

Artifacts were integral to exploring ideas and creating common understanding. In both studies discussing paper drawings in a group was common practice. Discussion around the artifacts contributed to the evolution of the design and allowed information represented in them to be highlighted, criticized, changed provisionally, and confirmed, at which point the artifact, typically a drawing, could be modified. Artifacts were therefore a resource for discussion, although they were also generated and modified through these discussions.

2.1.3 Designing Engineers, Object Worlds, and Ecology

Bucciarelli's ethnographic work on designing engineers used the concepts of *object worlds* and *ecology* to denote the social and artifactual nature of designing [1]. An object world is "a domain of thought, action, and artifact within which designers move and live when working on any specific aspect, instrumental part, subsystem, or subfunction of a whole design." An object world includes artifacts such as mechanical apparatuses and logbooks, but also includes mathematical relationships, symbols, techniques, and methods used to design. All participants in design function within their respective object worlds.

Bucciarelli warns, however, that fixing only on the objects that comprise object worlds would be reductionist: "Contemporary design is, in most instances, a complex affair in which participants with different responsibilities and interests--that is, working within different object worlds--must bring their stories into coherence…Object worlds are not congruent. Interest conflict, trade-offs must be made among different domains, and negotiation is necessary [1]." Design, Bucciarelli notes, is a social process as much as it is getting things right within object worlds. The concept of *ecology* of design suggests an organic, dynamic design process in which designers are sustained by an infrastructure (a domain of resources) from which they draw and to which they contribute.

2.1.4 Visual Representations in Engineering Design

In her ethnographic work on the use of visual representations in engineering design, Henderson (1999) found that visual representations had an ability to be a holding ground for and negotiation space for explicit and tacit knowledge [3]. Visual representations were malleable as they could be drawn interactively, shaped, and redrawn. The visual representations facilitated the joining of multiple meanings with their ability to: transform other ways of knowing, such as verbal and mathematical modes, into a visual format; elicit tacit knowledge from participants so that it can be represented in a format readable to others; represent knowledge through the flexibility of sketching in an uncoded format; tap all sorts of visual modes of representation spanning all of the world's art forms and history, including the abstract; develop and standardize a new lexicon to maintain consistency of meaning; represent different ways of knowing using many different systems of representation at once, including verbal, mathematical, and numerous visual modes;

2.2 A theory of culture, cognition, and artifacts

Above I described ethnographic studies of design, but there are also studies of cognition, that are not about design per se, but that are relevant to the study of design as a social and artifactual process [5, 6]. These studies are based on the work of the Russian psychologist Lev Vygotsky who sought to avoid dichotomies between thought and action and between individuals and society. The initial premise of Vygotsky's school of thought is that human psychological processes emerged at the same time that humans began to modify material objects to create artifacts, including tools and language [6].

2.2.1 Artifacts and the Creation of Shared Meaning

Hutchins (1995) conceives of culture as an adaptive process that occurs both inside and outside the mind. Learning involves the coordination of representations and the world. Understanding a procedure may depend on understanding the state of the world in which a task is to be carried out. But in order to understand a task, there must be experience with the descriptions and meanings of the task steps. With greater experience, the actor begins to internalize external information and becomes a sort of medium for coordination of media and other actors. Interaction between internal cognition and external structures produces the group-level cognition that is important to human society.

All human societies face cognitive tasks that are beyond the capabilities of any individual member. Even the simplest culture contains more information than could be learned by any individual in a life time, so the tasks of learning, remembering, and transmitting cultural knowledge are inevitably distributed. The performance of cognitive tasks that exceed individual abilities is always shaped by a social organization of distributed cognition [5].

Hutchins argues for the reconceptualization of cognition as an adaptive system of internal processes, tool use, and social interactions. Engaging in an activity propagates changes in the cognitive system (such as learning) that produce still more changes in the system, such as the creation of new internal processes, social interactions, and tools. While Hutchins' focus is on cognition and not artifacts, he provides a way of understanding how social and artifactual design could be seen as a cultural-cognitive process. Design is social because it occurs within the larger social infrastructure of

organizations, but it is also a non-linear process of exchange whereby shared meanings are created between members of a design team.

3 THE RESEARCH: AN ETHNOGRAPHIC STUDY OF MUSEUM EXHIBITION DESIGNERS

This research used ethnographic methods and documentary analysis to study the artifacts and surrounding practices of an interdisciplinary team of museum employees as they designed a large museum exhibition. The research questions were: How do members of a design group comprised of people from different communities of practice collaborate; and how are artifacts used by the design group?

This research used ethnographic methods such as participant-observation and interviewing and also used documentary analysis to analyze the contents of documents used. Data was collected at the Natural History Museum for over a year between the months of December 2001 and March 2003. During this time 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. I have used pseudonyms for the names of people and places to protect the privacy of individuals who have participated in this research.

3.1 The Exhibition Design Project and Design Team

This research followed a design project that was undertaken by a large natural history museum, hereafter referred to as the Natural History Museum and the project was to create a traveling exhibition about wild and domestic dogs from scratch. An interdisciplinary team of designers 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 there was a peripheral group of participants who made occasional contributions through participation in meetings or the 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 scientific advisors/curators.

3.2 Theoretical Inspiration for the Study

Two theoretical constructs that are useful for understanding design as a social and artifactual process are Wenger's *communities of practice* framework [7] and Star's concept of *boundary objects* [8]. *Communities of practice* are social configurations where people engage in practices, negotiate meaning, and create their identities. A community of practice is identifiable through participation in mutual engagement. Through mutual engagement over time, the people from these disparate departments develop shared memories and practices and over time become a community of practice. Communities of practice do not necessarily map to organizational divisions.

The phenomenon of boundary objects illustrates how disparate groups, such as scientists and amateur naturalists, are able to collaborate. Design work, as with scientific work, also requires collaboration among disparate groups. Boundary objects arise over time from durable cooperation among communities of practice. Boundary object are objects that both inhabit several communities of practice and satisfy the informational requirements of each of them [9]. Boundary objects can adapt to local needs and constraints of the several parties employing them, yet maintain a common identity across sites.

Standardization is a defining element of a boundary objects. This being the case, one wonders where do boundary objects come from and whether interdisciplinary design teams are using artifacts that are not actually boundary objects. If boundary objects are understood as objects that coordinate the perspectives of communities of practice, then the study of how boundary objects are used and created are key to understanding design. Building from the concept of boundary objects [9] and communities of practice [7], I describe artifacts that negotiate boundaries between communities of practice that are similar to, but quite distinct from the phenomenon of boundary objects. Finally, I coin the term *boundary negotiating artifacts* to describe several ideal types of artifacts that each play a special role in the negotiation of boundaries between communities of practice.

4 SUMMARY OF RESEARCH FINDINGS

4.1 The Dogs Group as Intersection Between Communities of Practice

Design is fraught with conflict. Rather than characterizing such contests as a battle of individual wills, it is helpful to explore the Dogs group as an intersection between different communities of practice. In a very real way, the members of the Dogs group brought sets of practices, values, and meanings with them to work. Some of these practices are embodied in staff member's know-how and expertise regarding exhibit-oriented reifications (e.g. how to build a kiosk, how to write at a certain grade level), but along with task-oriented practical skills, communities of practice teach members related practices, attitudes, and norms as well. Sometimes these practices, attitudes, and norms conflict directly with those of other members of the Dogs group.

Interviews revealed that each team member had multiple self-identified affiliations to communities of practice such as departments, functional units within departments, previous occupations, education, training, other museum genres, and professional associations. The each cited these affiliations as motivation for specific actions

4.2 Invisible Affiliations and Characterizing Conflicts

Perhaps most interesting about the contests in the collaboration between communities of practice was to what extent the communities of practice could be invisible to participants. The curators worked on the project off and on over a period of two years and yet never became privy to the communities of practice at work within the museum. Certainly they understood that there were conflicts and that different people had different jobs, but even after the exhibition had been successfully opened they were unclear about the roles of each of the team members and to what extent they had been involved in the creation of the exhibition. They certainly never came to understand what functional units were involved in the creation of Dogs and that they mapped to different communities of practice.

The curators were never privy to the participation and affiliation of three key team members in a professional museum studies association that advocated a reduced role for exhibition curators. Knowledge of the philosophical differences engendered by this association, would likely have changed the way that things transpired amongst the team if not the ultimate outcome. While not always resolved to universal satisfaction, the conflicts and negotiations that occurred enabled the team to coordinate themselves and successfully collaborate to produce a complicated museum exhibition.

4.3 Boundary Negotiating Artifacts

This research found designers using artifacts and surrounding practices to iteratively coordinate perspectives and to bring disparate communities of practice into alignment, often temporarily, to solve specific design problems that are part of a larger design project. I observed the use of five types of artifacts, each created for specific purposes and used differently. Four types of artifacts were created for crossing boundaries between communities of practice: compilation, inclusion, structuring, and borrowing. Self-explanation artifacts, a fifth artifact type, were created by and for either a single individual or two to three members of the same community of practice working in tight collaboration.

- *Self-explanation artifacts* (e.g. notes, tables, concept sketches) were the most difficult to study as they were rarely presented directly to others and were typically created while Dogs group members worked in the privacy of their offices. The designers used self-explanation artifacts for learning, recording, organizing, remembering, and reflecting. While created and used privately, self-explanation artifacts were sometimes indirectly presented to others through the creation of inclusion artifacts or compilation artifacts.
- *Inclusion artifacts* were used to propose new concepts and forms. These artifacts were created from self-explanation artifacts and from submitted concepts and forms to go through a screening process of group discussion whereby an idea embodying different concepts and forms (e.g. sketches or text) originating from one community of practice would be proposed to others. This screening process entailed communal gatekeeping whereby the group would use the inclusion artifact as a reference or symbol for the new idea.
- *Compilation artifacts* (e.g. tables, technical sketches) were used to coordinate both media and the designers themselves. The designers used compilation artifacts to bring two or more communities of practice into alignment just long enough to develop a shared and mutually agreeable understanding of a problem and to pass crucial information from one community of practice to another. This process of alignment and sharing of information facilitated the creation of shared understanding about each exhibit and the exhibition as a whole. This process of alignment was continually necessary as knowledge was distributed across functional specialties (e.g. sculpture, taxidermy, education, etc.) and elements of each exhibit were constantly evolving. While inclusion and compilation artifacts often fully or partially incorporated self-explanation artifacts, structuring artifacts often fully or partially incorporated inclusion and compilation artifacts.
- *Structuring artifacts* (e.g. exhibition narrative, exhibition concept map) were plentiful throughout the design of the Dogs exhibition. The structuring artifacts created by different members of the Dogs team often competed with each other for primacy. The curators, the educators, and one of the exhibit designers each had a vision for the exhibition and their vision was made manifest in their structuring documents and their expectations for how their structuring documents would be used. Like compilation artifacts, structuring artifacts are used to coordinate media and understanding but, unlike compilation artifacts, structuring artifacts are also used to establish ordering principles, establish tenor in narrative forms, and to direct and coordinate the activity of others. Structuring artifacts were often at the center of heated struggles between

communities of practices and at times seemed to work to push and negotiate boundaries themselves--quite different from boundary objects which move across boundaries from one community of practice to another with relative ease.

- *Borrowed artifacts* are used by designers to augment their understanding of design problems. A borrowed artifact is one that is taken from its creator in one community of practice and used in unanticipated ways by those in another community of practice. The practice of borrowing occurs when communities of practice are in close proximity.

Each type of artifact is entangled in a mesh of practices. The Dogs group was relatively unaccustomed to working together and was also unaccustomed to working on a project of this size and complexity so some practices were more evolved than others. The practices surrounding self-explanation were fairly evolved because each team member had years of specialized experience with artifacts in their own field. Each team member had years of specialized training and experience that helped them create self-explanation artifacts for recording and analyzing ideas in ways that were understandable and helpful to themselves and to those from similar backgrounds.

The practices surrounding inclusion artifacts were fairly simple: involving creating and proposing on the part of the artifact's creator; and accepting, rejecting, or reserving judgment on the part of the receivers (the other communities of practice). Including, and the related practices of accepting and rejecting, took up a great deal of time during the meetings of the Dogs group. These practices were stable and occasionally including practices would take place without the actual creation of an inclusion artifact.

Unlike with self-explanation and inclusion artifacts, the practices surrounding compilation artifacts and structuring artifacts were not well-developed and required the development of new practices. This resulted in confusion and conflict. The curators, educators, and the exhibit designer each produced their own structuring artifacts and they each had their own expectations for how their own artifacts and those of others would be used.

Boundary negotiating artifacts are used to: record, organize, explore and share ideas; introduce concepts and techniques; create alliances; create a venue for the exchange of information; augment brokering activities; and create shared understanding about specific design problems. The taxonomy of boundary negotiating artifacts and its sub-concepts of inclusion, self-explanation, compilation, structuring, and borrowed artifacts illustrates artifacts in the context of their use. This research has not documented the emergence of any particular boundary object, and the actual standardization of a boundary object may involve elements other than those described in this work. However, this research suggests how boundary objects might arise from the collaboration of disparate communities of practice over time and through the creation and use of intermediary artifacts.

5 IMPLICATIONS FOR DESIGN EDUCATION

This research has briefly sketched a taxonomy that articulates how design teams use artifacts in order to coordinate, learn, and negotiate boundaries amongst themselves. The implications of this research, and its predecessors, has implications for design education, particularly design curricula.

Design students would benefit from a curriculum that cultivates an understanding of collaborative design as being simultaneously and essentially social and artifactual. I

would propose amending design curricula to include a Sociology of Design that would provide students with a more sophisticated understanding of the dynamics of teamwork and the nature of group learning which is at the core of so much design work. The importance of artifacts and social activity to design has been documented in various ethnographic studies of collaborative design including this one.

This article introduces the concept of boundary negotiating artifacts and the sub-categories of self-explanation, inclusion, compilation, structuring, and borrowed artifacts. Introducing students to the concept of boundary negotiating artifacts and its surrounding concepts can help students to think analytically about designing collaboratively. An understanding of boundary negotiating artifacts can also help students understand the weaknesses and strengths of using artifacts to communicate; Artifacts must not be thought to be self explanatory.

Teaching students about boundary negotiating artifacts would also encourage design students to be more cognizant of the process of "designing design"; Students would become more attuned to the potential for re-use of intermediary artifacts used to create mutual understanding. Finally, students would acquire a more complete understanding of the complex interactions that make collaboration possible and how they can more successfully collaborate with others.

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