

COMPUTING AND THE SOCIAL NATURE OF DESIGN

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Abstract. Design is fundamentally a social activity; through a series of projects that examined groups of designers engaged in real design activity, a model of design communications as the mutual building a shared understanding leads us to a different approach in which computing is used not in service of the individual, but of the group and as part of a larger fabric of communications technologies. These projects have resulted in a collection of prototype electronic design environments called "Media Spaces". Media Spaces are made of audio, video and computing systems that connect designers across time and space. The case studies and the development, refinement, and extension of Media Spaces are tightly coupled. The analysis of these studies yields insights into the nature of communications and documentation in design. The cycle is completed with the development of new systems that integrate computing into design, embodying the principles uncovered in the analysis.

1. Introduction

Computing may have improved processes around design, but it has done little to improve the practice of design itself. In fact, a case can be made that computing has made it worse. What follows is one explanation for this failure and a few projects that have been carried out that suggest an alternative.

This work is built on a few very specific (and possibly controversial) premises about design:

- Design is the act of making something new that fits with reality. Design is not unbridled imagination, but a fit with the world and its messy and contradictory conflicts. This definition is inclusive -- it takes in all the influences that generate and shape the final result. (Caplan, 1982; Sults, 1985)
- Design is the social process of constructing a technical reality. Like jazz, creativity flows from the interplay of individuals. This interplay is visible in their communications: conversation, drawings, gesture, etc. The social process is the aggregation of separate roles, activities, and responsibilities. The aggregation is a result of imagination, conversation, experience, power relations, interpersonal dynamics, persuasion, and personal insight. (Cuff, 1991; Minneman, 1991)
- Design is experiential; it exists in the moment; it is taught by doing; and so it is not adequately described in external representations. The act of designing changes the designer, making it impossible for the same design to truly be done twice.

To understand the implications of this, we need to consider the roles of social setting and communications in design. This will provide a new critique of existing uses of computing and an explanation of development of new technologies to support design. It also leads to a research method

where observations of real creative activity are closely coupled with the development of new technology. The application of this method and the resulting technologies will be illustrated by a few demonstration projects.

2. A Creative Work Setting

This approach to the study of design process begins by looking at the everyday setting of creative work--the architectural design studio.¹ From the setting and the activities that designers engage in, it is possible to make a few observations of the details of design practice.

2.1 THE ORGANIZATION OF WORK

Work is divided into projects. It is around the project that resources are marshaled, documents prepared, agreements made, and billings generated. From a social standpoint, projects also give a common point of reference to work, provide a shared experience, and shape the language, enriching and particularizing meaning for project members.

2.2 VISIBLE ACTIVITY

In a design studio what are people doing? We see people drawing intently, discussing drawings and product specifications, talking on the phone, sketching alone and together, opening mail, carrying piles of paper, holding intense conversations, joking, and gossiping. Someone may rummage through a file drawer and ask over her shoulder to everyone within earshot, "What was the project that used steel sash windows? Does anyone know how that was detailed?" At times sizeable groups of people are away from

¹ While this paper uses architecture as its central example, it does so a convenient package. Aspects of creative endeavor discussed here are found everywhere.

the studio: out in the field, meeting with clients and consultants, or just gathered around a conference table in an adjacent conference room.

2.3 THE PHYSICAL SETTING

What is the physical arrangement of designers and how does it affect work? Consider the archetypal studio: the designers sit in a one large room where most discussion, phone calls, drawings, and comings and goings are available for everyone to see and hear. Usually, work appears to be carried out separately with designers hunched over their drafting tables. But it is open work, available for kibitzing or impromptu review and explanation. In the idle chitchat, the questions asked across the room, and the occasional public announcements of birthdays and promotions, the open work culture builds on the open physical space, reinforces the awareness of the activity of others and the progress of the projects.

2.4 ENROLLMENT OF PARTICIPANTS

There are varying degrees of interaction and engagement, ranging from formal job meetings to charettes to brief desk crits to overheard snippets of casual conversation. At various times throughout a project these participants function as a group. When participants form a group, they must maintain working relations within it. They do this by "buying into" the goals of a project. Enrollment has a quality of ownership, a personal investment in the emerging artifact. This personal investment results in each participant wanting the artifact to reflect the results of their negotiations.

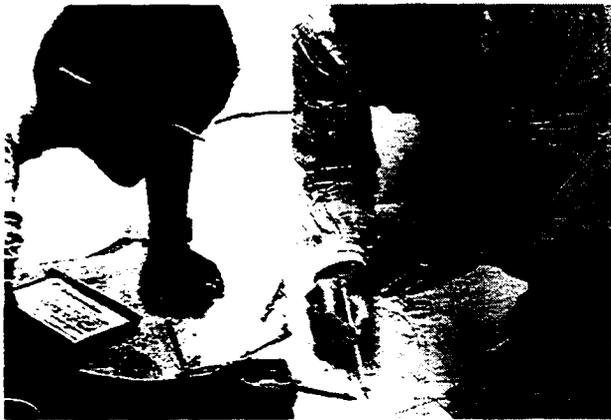


Fig 1. Designers working together on a an idea.

3. Design Communications

Is there some way to understand this scene and make use of it to improve design practice? Let us consider the obvious visible phenomena--the communications between designers;

it is in the communications that project knowledge is represented.

There are two versions of the story that describes communications in design: the "official" one that communications are used to transmit specification and the "unofficial" story that design communications are the vehicle for developing the shared understanding among the various players. It is not that the official story is wrong, but it is only a small piece of the story. It leads to the development of tools that are at best peripheral to design activity.

3.1 THE "OFFICIAL" STORY

In the official version of design communications, information flows are well defined: in the case of architectural practice, clients deliver a clear statement of requirements that is acted on by the architect to produce a set of drawings and written specifications that are used to erect a building. Information content increases as the project proceeds; sketches are refined into drawings with increasing degrees of precision. Designers share information at meetings where conflicts are resolved. Discrepancies in design documents are a human failing and completely avoidable with more and better information. (Mitchell, 1977; Mitchell, 1990)

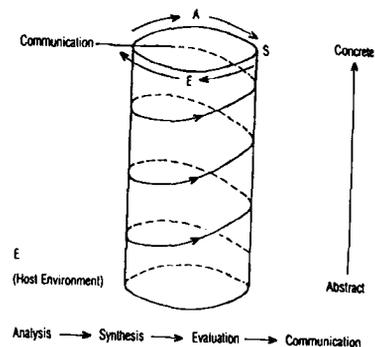


Fig 2. Asimov's model is one of the earliest examples of the official story. Reproduced in Rowe, 1987, along with other procedural models of design process.

3.2 THE "UNOFFICIAL" STORY

In contrast with the official story, looking at the actual goings-on in design reveals a very messy story involving lots of talking, sketching, and gesture; the settings where these occur are not always well organized or documented. Using some ethnographic methods, these everyday activities add up to a communications-based view of design.

Just as this is not a problem-solving view of design, neither is it an information theoretic view of communication. Although the content of design communications is describable in information terms, the communications are subtle, mutually developed among the parties, and highly contextual. This can be illustrated by a couple of the aspects of

communications in a social context: sketching and ambiguity.

Sketching. Consider the *role* of sketching when two or more people are working together. While sketches very often are used to individually work through ideas, they are also very important in conversation. The canonical “cocktail napkin sketch” is usually most meaningful when combined with the conversation that went on during its production. Sketches can serve as representative of some object or idea; they can be “frozen gestures”; and they are often most useful as things that are pointed at during a conversation. This last point, called *dyxis*, points out how something as ubiquitous in the design process, and as highly personal as sketching requires a social context in order to be useful. (Bly, 1988; Tang, 1989)

Ambiguity. Design works in the tension between explicitness and implicitness; therefore, ambiguity is a common and healthy characteristic of communications in a design group. The degree of ambiguity is the key to providing the “communications space” for a common understanding to develop through exploration and explication. Ambiguous communications provide an opportunity for designers to project and reflect — breathing room from rational concerns. Designers project a story onto suggestive fragments to make a whole, creating the shared understanding.¹

The phenomena of design communications are the most visible and accessible parts of the design process to those on the outside. As an outside observer, it is easy to confuse the communications with the whole story of design activity. The communications can engender and demonstrate activity while not being the activity itself. For example, someone may ask the question, “How big is it?”, which is answered by “About 4 inches.” The answer probably required some calculation and an understanding of the complex context in which it was asked. But the common “truth” of the design activity, the one that is shared by the group, is the question and the answer. Thus, it is more than a data collection and reduction technique, it is the greatest common denominator with which a group defines itself. (Harrison, 1987)

Two kinds of ambiguous communications appear frequently in creative interchanges: confusion between the symbol and its object, and multiple meanings for the same symbol. Ambiguity and misunderstanding lead to a colorful, exciting world. Any complete model of a design process must be capable of reflecting the uncertain, fanciful, and ambiguous states of our minds.

Shared Understanding. The result of all of these conditions is the development of shared understanding about the final outcome. There are formal ways in which ideas are con-

veyed, but it is the development of the understanding that is at the heart of the social nature of design. (Minneman, 1991)

Distance and Complexity. Confounding both the official story and the unofficial story is the problem of distance — not everyone works in the drafting room. What happens to design when people become cut off from each other by walls, miles, time zones, or the pressure of other work? How can designers work with other designers, with consulting engineers, their clients, or contractors without being present? Design activities become discontinuous — fragmented by meetings, telephone calls, and presentations made across town (or halfway around the world). The organizational response to this has been increasing bureaucratization of process at the cost of stifling creative activity. The distances and discontinuities are increasing as we design and erect more complex buildings that are further removed from the offices of designers, clients, contractors, and suppliers.

4. Some Limitations of Current Computing Systems

What can be said about the ability of computing tools to address the unofficial, social story of design communications? The fluid and shifting relationships between people that are so clear when pencils and hands dart across yellow tracing paper are lost on PERT charts and CAD drawings. Computing (as currently constituted) fails as communications because it is unrealistically bureaucratic, it is difficult to communicate ambiguously, and people remain estranged from, not engaged with, the group.² The cost of the seemingly infinite malleability of computing is regimented and reductive compartmentalization.

Applications in current design practice flow from the official story -- the refinement and ordering of information: text processing for specifications, computer-aided drafting (CAD), rendering, engineering and environmental analysis, project management, and accounting. Even new applications, such as hypertext based-IBIS, characterize the design process in a similar way. Lets briefly analyze these in terms of the unofficial story:

CAD is a very useful documentation tool, but it has not proven itself equally useful as an open-ended design tool for architects. The visual and dynamic nature of design makes it particularly unsuited to textual or computational representation. The computational environment -- like its progenitor, text -- generally eliminates multiple meanings. In doing so, it creates a static set of ideas that leave little latitude for expression and interpretation.

This same requirement for precise specification also makes CAD hard to work on together. It works best when

¹ A parallel line of argument about individual design process can be made, leading to a reformulation of the role of computers for individual designers; for example, Coyne (1992) talks about “metaphor”.

² Another, more radical formulation of the same analysis is that it is fundamentally text-based. As McLuhan (1964) points out, the break from oral culture to print culture changed how we see the world and relate to others in it.

most rigorously structured along the functional lines of the design organization (architectural, structural, HVAC, and electrical), and the conceptual hierarchy of the building (column lines, partitions, and exterior walls). This partitioning blocks access to the gestalt of a design - it must always be seen as the sum of its constituents. Losing the gestalt, in turn, blocks shared understanding and further distances designers from the project and each other.

A similar critique can be applied at the other end of the tools spectrum to Horst Rittel's issue-based information system (IBIS). While much progress has been made in developing shared hypertext environments that support the development of issues and rationale, the structuring of arguments abstracts it from the social fabric where the development of a shared understanding takes place. [Rittel (72); Conklin and Begeman (87); Fischer et. al. (89)]

5. An Alternative Approach

One approach is to develop computing tools that support the rich communications of designers across its many, varied, and subtle range. One approach that we have taken has been to develop systems that radically downplay the textual basis of computing while emphasizing visual and acoustic connection. The systems, called media spaces, can connect designers across time and space. Media spaces support both real-time connection (formal meetings, group brainstorm, social gatherings, office-to-office discussions, and informal encounters) and the creation and management of multimedia documents. Video can connect people who are

temporally and physically separated; how people can act as belonging to a group through both real-time and recorded video interactions; how video supports most free-wheeling negotiations; and how well the subtleties of nuance, gesture, and presence are conveyed, supporting ambiguous interactions.¹

The method of this research has been to tightly couple the study of design and the development of systems. This has resulted in a series of "multidimensional" electronic work places for designers. The work places are multidimensional in that existing design activity is extended in ways that build on the social skills and yet bring people and the artifacts of their work into closer relation.

We explored this vision over a series of studies of real designers: the House Addition Project, the Office Design Project, the Mechanical Design Study, the Design Communication Workshops, and Design Place '90.

5.1 HOUSE ADDITON DESIGN PROJECT

A small architectural design project was tracked from conception through building occupancy using video to record the project. The recordings depict aspects of a design process that are nearly invisible in computation-based records and demonstrate the possibility for using video to provide connection within a design group. Designers and client used video recordings to track design decisions made in their absence. (Stults, 1988)

¹ See the Appendix: The Media Space Vision for a discussion of the media space as a unified design environment.

	SETTING	PROBLEM	APPROACH
Office Design Project (ODP)	Distributed 4 People Conceptual Design Close working relations (Architecture)	Supporting Real-Time Design Negotiation (at a distance) !?! ?!?	 <small>A visualization formed by several Media Space elements.</small>
Mechanical Design Project (MD88)	Distributed 8-20 People Design & Development Casual working relations (Mechanical Engineering)	Supporting Asynchronous Engineering Communication (Project Coordination) !	
Design Communications Workshops (DCW)	Interdepartmental Organizations Conflicting Goals Conceptual Design Group-to-group relations (Product Design)	Developing Asynchronous Organizational Understanding ! ? !	
Design Place '90 (DP90)	Remote One to One One to Few Close working relations Transit to Manufacturing Organizations (Product Development)	Supporting Real-Time Communications About Objects at a Distance ?	

Fig. 3. The foci of design process explorations and uses of media space technologies in studies of design practice.

5.2 OFFICE DESIGN PROJECT

The Office Design Project (ODP), in 1987, used recorded and real-time audio and video connection to create a virtual design "studio" for three architects to work together while in physically separate locations. The studio was designed to support conceptual design work. In conceptual design, the work is mainly creative, requiring less document retrieval and more freewheeling social space. The designers were able to converse over video links and could use video discs to gain access to recorded material; the studio did not provide access to scaled drawings, CADD, or furniture catalogs. This project gave us a glimpse at how the social relations of synchronous design activity could be supported in a spatially distributed setting. (Weber and Minneman, 1988)

5.3 SHARED DRAWING

The multi-disciplinary team that carried out the ODP included a number of people who had coincident research agendas. This collaboration resulted in synergies in both the creation of the studio and on future research. One of the synergies that resulted was the idea that collaborative real-time work might be facilitated by shared working surfaces — the lack thereof was also becoming problematic in our day-to-day use of the Media Space. In ODP, the designers briefly used tracing paper to accomplish this. Coupled with analysis of the role of diegetic reference, a project to study shared drawing was created that produced some real-time tools: Commune and VideoDraw. Both provide designers who are collaborating remotely with a common display surface in which gesturing and drawing are visible to all users simultaneously. Commune is a computationally-based approach that intermingles pointing and marking; VideoDraw is video-based, permitting hand gestures to be directly viewed along with the marks. Both the projects that led to the development of these tools, and the explorations where they have been utilized, emphasized conceptual design work and rarely required three-dimensional artifacts or operations. (Tang and Minneman, 1990; Minneman and Bly, 1991)

5.4 MECHANICAL DESIGN STUDY

The Mechanical Design Study (MD88) convinced us that the complexity of real projects are necessary to understand how our ideas work in actual practice. The project — simple on the face of it: supply a group of electro-mechanical engineering designers with video equipment and observe how it changes their communications — required a great deal of preparation to identify a group to observe, to build the trusting working relations with them and their management, and to scale the study to the activities of the group. This initial effort was repaid with a rich demonstration of video documents in use in a real setting.

MD88 revealed how projects in industrial settings are characterized by a rich and complex network of interactions and negotiations between parties with particular interests

and perspectives. The asynchronous (recording, editing, and playback) video services we brought to this setting showed promise for sharing perspectives and project status; negotiation through time-shifted media was troublesome. The study demonstrated roles that video might play in maintaining process awareness in larger design teams.

5.5 DESIGN COMMUNICATIONS WORKSHOPS

In the Design Communications Workshops (DCW), participants carried out a simulated product planning process within a hypothetical manufacturing company. The exercise was developed to further reveal particular aspects of distributed design work that were coming to fore in the MD88 effort. In contrast to ODP where the group size was small, DCW were an attempt to better understand communication within and among groups of designers working on large, distributed projects. In the planning process, the workshop participants played roles in the company's marketing, engineering, and manufacturing divisions. The workshop focused on the use of video to support the complex social interactions within and among the company's divisions.

The communications between the groups were restricted to a few media and the exercise was structured to expose the effects of selecting one medium over another. The groups sent video "memos" to each other. They were quickly made using camcorders and vcr's. The memos conveyed some sense of the degree of agreement on various points and overall intention within a group. Groups began to get a sense of all the members of the project and understand how they "fit" within the development of it. Video memos also allowed distant designers to "get inside" and point at specific problems they were having; they could show what was wrong and how they proposed to solve it by pointing and talking, just as if they had brought the machinery into the design studio.

The workshop setting has proven to be effective at educating designers about designing in organizations, about use of media in designing, and a testbed for various Media Space technologies. (Harrison and Minneman, 1989)

5.6 DESIGN PLACE OF THE 90'S

Most recently, in the Design Place '90 (DP90) project, two designers worked remotely from their 50-person industrial design firm for two weeks using a specially tailored media space that kept them present in their normal work environment. The focus here was on the communications during the transit from design to manufacturing — a critical element of any design effort and one that is reputed to be dramatically different in concurrent engineering efforts. Design studies to date have focused on supporting conceptual design activity — sketching, working at whiteboards, and the like — it is claimed that here is where costly design mistakes may be made. Since most design time is spent in design development and documentation for manufacturing, cutting time-to-market means cutting this phase. It is in this

phase that things get real, so the communications are about real things — prototypes, vendor samples, and test assemblies. DP90 exposed new areas for technological development by necessitating support of communications about, and documentation of, real objects and their processes.

6. Conclusion

In each of these projects, designers with real needs, clocked by schedules and driven from client requirements, used video and audio to maintain the social relations that constitute the framework for design activity. The design work ranged from conceptual architectural design (ODP and DCW) to prototype design and testing (MD88) to design documentation (DP90). Just as the types of activities changed with each project, so did the electronic settings: in some cases the technology provided the ability to converse in real-time over video links and use videodiscs to gain access to prerecorded material, in others, videotape was used to keep members present in the project. The same kinds of representations that were used in conceptual design were used again in design documentation, transformed by the context of use, instead of through abstract computational processes. It is this socially-based awareness and synchronization of activity that we believe is the basis of successful design.

These projects, and the perspectives they embody, represent critical and heretofore neglected aspects of supporting design teams that are subject to spatial and temporal separation. Repeated exposure to real designers doing real design work has contributed to the development and ongoing refinement of new tools for distributed design settings.

7. Appendix

THE MEDIA SPACE VISION

What is a Media Space?

It is a system that integrates video, audio, and computer technologies, allowing individuals and groups to create environments that span physically and temporally disjoint places, events, and realities. It is also a way of working — of being “media aware” — that brings the illusionary power of media into everyday work.

No, Really, What is a Media Space?

In a physical sense, cameras and monitors are placed near drafting tables, desks, conference tables, CADD stations, diazo printers, and coffee pots—wherever people gather at work. The cameras and monitors are linked to each other and to recorders and videodisc players that provide a library of interactions that can be retrieved as an integral part of routine work. These local area audio and video networks can be connected together in remote point-to-point configurations. Subsets of the larger group can then connect

themselves together to form project teams that are in the same virtual room or out to a remote location like a job site.

The video can be used as an open window from one space to another and, by using recordings (both videotape and videodisc), from one time to another. Instead of physically relocating, virtual groups can be formed by reconfiguring the electronic connections between offices. Video images keep the participants in touch with others who are absent - temporally, physically, or both. Media Space defies walls and clocks. (Stults, 1986)

Coordination of the connections is accomplished using the networks of computers that are already in the workplace for word processing, accounting, project management, and CADD. In addition to controlling access to devices, they are

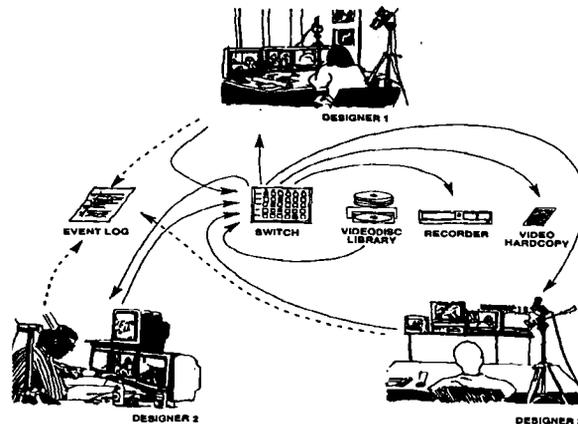


Fig 4. The Media Space at PARC.

used to organize the video records of the design activity, index and access the recorded material being collected and viewed, collect data about how the material is accessed, and provide groups with the ability to mark their activity (flagging places in their process they or others might want to revisit).

Combining recording and real-time connection has a great systemic synergy: adding a recording capability to real-time connection is cheap and provides a useful journaling service to users, and having retrievable recording makes real-time connection much more than a “picturephone”. For example, we frequently use this facility in our everyday work to record meetings that someone else might have a peripheral interest in. By watching snippets of the recordings, the absent individual can stay apprised of an activity without a big time investment. (Bly et. al. 1993)

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