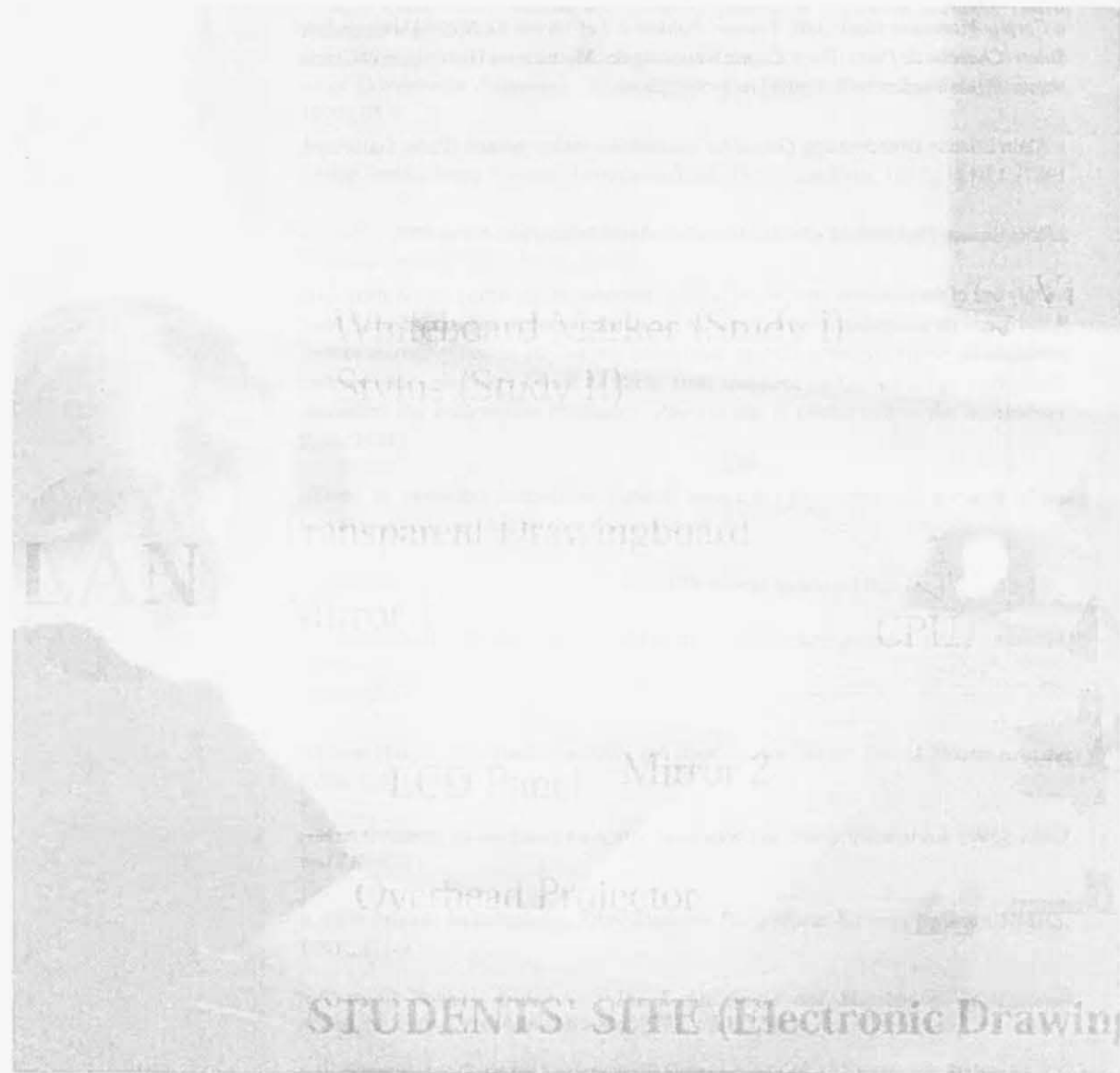


Manual Media for Collaborative Digital Design



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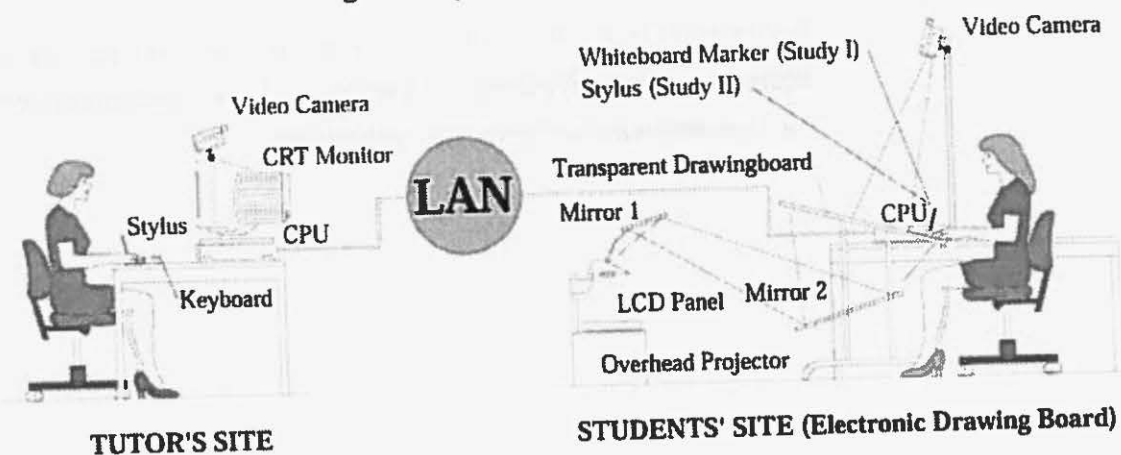
Information technology (IT) creates new demands on the way we design. Collaborative design in a networked environment is one of the significant influences of this technology.

Collaboration by IT began with providing data transfer from one terminal to another, or, in a more sophisticated way in integrated systems, by supporting joint access to a single, central, non-redundant project database. Its utility and productivity have been founded greatest in the Computer Aided Design (CAD) industry. However, designing is not simply a technical process, but also fundamentally a social one. In design practice, discussion and negotiation processes are fundamental components of technical problem-solving. Therefore, these processes should be supported by the computer environment in which design tasks take place (Mitchell, 1995).

However, it is difficult to apply this paradigm to existing CAD systems because CAD systems mainly apply to the requirements of precise documentations. Thus they provide an environment for contract/working drawing rather than for communicating at the sketch design stage. To understand the importance of this, let us consider traditional design teamwork in which designers sit around drawings of a design proposal at a drawing board. As part of the design process, they point at the drawing, draw and erase on it, and move between drawings. These actions are facilitated by quick ambiguous media of communication such as manual sketches. Precision drawing, on the other hand, seems to be facilitated either by working alone or by dividing and managing the documentation task within a team.

What follows is a discussion of how the media of IT, such as video conferencing, might affect the nature of communication and design processes in the design studio by investigating the relation between manual and digital media. In this paper, I report on case studies using IT for collaborative work across computer networks in the setting of the design tutorial as an illustration of new ways of working together. The paper recognises the difference in using of manual media in the act of digital input devices as opposed to other ways of working with digital media.

The studio setting was a collaborative workshop with tutor and students working in separated locations. The media for the studio included both manual and digital, and related technologies at each node of the collaborative network. These media worked together through the sharing of digital images, verbal communication of the design process. They were all achieved across Local Area Networks (LANs). Both tutor and students participated in an integrated digital drawing environment connected through video



conferencing technologies. The studio described here is not unique or novel, but builds on the studies of the Media Space (Stults, 1986) and the Virtual Design Studio (Mitchell et al, 1995). In this paper, the studio constitutes a case study that provides interesting insight into an understanding of the relationship between digital and manual media.

THE ROLE OF INSTANTANEOUS INTERACTION IN DESIGN COLLABORATION

"Design is the process of socially constructing a technical reality. It is not the work of individual designers, but the interplay of individual work and relations between designers" (Minneman, 1991). In this sense, designing may be understood as a form of collaboration. In the early stages of design, collaboration is often among designers or between the designer and clients. This can affect the direction of design or designing itself. In the later stages of design, collaboration consists of interchange between designers and builders. Specialised form of design and more complex projects require greater collaboration in the design process.

Over the last few years, the fax has been involved in the construction industry as a tool to facilitate collaboration. In the use of this one-way digital image transmission tool, drawings on the paper are scanned into digital format, and then translated into analogue signals for transmission through phone lines. At the receiving end, the analogue signals are translated back into a digital bitmap image and printed out on the paper (Wojtowicz et al, 1995). This type of design collaboration is very remote or distant. It consists of two isolated sequential states of 'seeing' and 'drawing', invoking a paradigm of correspondence that is primitive and limiting. Despite its drawbacks, fax is still in incessant use in the industry, because of its simplicity, ubiquity and economy.

There are clearly situations in which sharing visual information is critical to design collaboration or at least makes interaction easier (Sellen, 1995). However, design collaboration is much more than just the exchange of visual information. Collaborative design is accompanied by a rich array of non-visual behaviour which designers use and respond to in communication, including instantaneous dialogue and direct interaction in a shared drawing space. The importance of being able to access shared drawing space simultaneously is crucial to collaborators' ability to negotiate their design communication smoothly (Tang et al, 1990). Simultaneous access also conveys in-depth understanding about the contexts of participants. (van Bakergem, 1995). It is, therefore, important to consider shared drawing space activities in which more than one designer interacts on the drawing space at the same time. This interaction on the drawing space can enable collaborators to observe and participate in the process of creating and referencing drawings rather than just seeing the resultant drawings. This allows designers to be receptive to each others' ideas and their interpretations for example, see (Tang et al, 1991).

At the same time, computer networking and the integration of video with computational devices have given designers the

opportunity to share visual information in a natural way.

This contributes towards establishing a rich and productive working environment, a feature lacking in existing analogue based systems such as fax. These technological advances provide instantaneous collaborative interaction among designers in remote locations.

The use of instantaneous interaction, a common function of computer supported collaborative work (CSCW), is one of the important issues emerging from my studies. Because of the unstructured activities of design communication, drawing helps to promote shared understanding among designers. As noted by Schön (1983), designing is a reflective conversation with drawing.

3. REMOTE TUTORIALS

In the studio, students and the tutor rely on computational design tools, computer networking technology and an integrated digital drawing environment such as the Electronic Drawing Board to help overcome the obstacles of separated space. The familiar traditional design studio has been translated to the computer-networked environment. The two studies explore various aspects of the collaborative design process and its supporting technology (Table 1).

Table 1. Configuration of the studies

	Participants	Environments	Interactive device
Study I	Tutor	CRT Monitor	Digitising tablet
	Student A	EDB	White board marker
Study II	Tutor	CRT Monitor	Digitising tablet
	Student B	EDB	Digitising tablet

Two dimensions are of particular interest in these studies. To understand the influence of integrated conventional modes of interaction with digital communication in a collaborative design situation is the basis for the first study. The second study identifies the difference between various modes of visual feedback the drawing board versus the screen. Pen-based interaction provides visual feedback at the point of input, whereas interaction using a digitising tablet and wireless stylus does not provide such feedback. These studies reveal:

- the relationship between manual and digital media;
- how IT media, such as video conferencing, affect the nature of communication;
- how IT media affect the design process and design.

The studies consist of observations and interviews, which were carried out in design tutorials to explore the conviction that design review could be feasible across networks. Three fifth-year students and a senior lecturer as design tutor, all from the Department of Architecture at the University of Edinburgh, participated in the studies. All participants were computer literate before the experiments began as they had used word processing, e-mail, a web browser and some CAD systems.

Before starting the design tutorial sessions, participants were given approximately 10 minutes to get acquainted with the configuration of remote tutorials. Following this, there were three individual design review sessions. These activities were observed and recorded on video as well as on 35 mm film. At the end of the tutorials, participants were asked to take part in interviews specifically to discuss how the environments of the two currently distinct media interacted in the design collaboration and the networked design tutorials they had just experienced. The interviews were structured around a number of research questions and hypotheses. The conversations were recorded on audio tapes, and these have been used as the focus for detailed analysis. A complete transcript was made of the audio taped conversation. The observations and the transcripts were used as a navigation device for locating specific incidents and as evidence for the views expressed in this paper.

The project was a final year architecture program in which the students' own theme would be developed throughout the academic year. Each student was to develop his/her own version of the design, recording his/her results in preliminary sketches, working drawing and models. At the end of the course, there was a crit at which the students presented their designs to the tutor and to a group of outside critics. During the course, the tutor held design reviews with each student (design tutorials) in the studio.

The studies took over one session of this regular tutorial and they took place late in the course. Instead of taking the periodical tutorial in their design studio, students were invited to come to our research lab for one day, whilst the tutor sat in front of her computer screen in her office rather than the traditional design studio.

In both studies, the principle of the system and choice of computer software were the same, with the exception of the interaction device. The student A, who explored the Study I, used a whiteboard marker as the input device. And the digitising tablet with wireless stylus was used as the input device for the Study II by student B. A schematic diagram of the two studies between two sites is shown in Figure 1.

The students' site was equipped with the Electronic Drawing Board (EDB), a standard dry erase whiteboard marker, a digitising tablet with wireless stylus, the Ethernet LANs and appropriate audio equipment, whose input was a microphone connected to the sound input port of the computer, and whose output was a pair of powered speakers, connected to the sound output port of the computer. Digital audio was unstable and so was supplemented by a normal telephone. The tutor's site was equipped with an audiovisual computer, a video camera, a digitising tablet with wireless stylus and appropriate audio equipment, as well as a telephone.

As is usual for a tutorial, the student placed a previously prepared drawing on the EDB to work out design problems with the tutor (Figure 2). And then she captured an image of the entire drawing with a videoconferencing software and pasted it in the shared

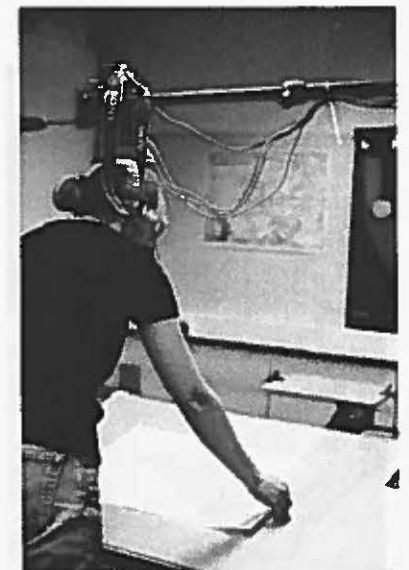


Figure 2

window to produce shared digital working environment. After that the student decided to remove the physical drawing from the EDB because she no longer needed it. She then started to point with a marker at the parts of the image so that she might present her approach and problems she had encountered.

During the tutorial, the tutor examined the image and then began to draw over the top of an image and to point with a cursor at the parts of the image with a wireless stylus. As she drew, she talked as well. However, her manuscript does not describe what was already there on the image but the manuscript contains many dyctic utterances such as "this", "that", "here"... The student interpreted only by observing the tutor's movements such as pointing and referring to images. It is possible to see the tutor's face but during the tutorial the student looked at the image mostly.

The tutor continuously demonstrated the working out of design solutions to achieve congruence of meaning. As the student became more confident, she moved to the next step in a way similar in actions to the design problem solution process.

In the work of these studies, two aspects of how the configuration provides the setting for the remote design review are as follows:

- The visual feedback, which is different from the space of input, seems to make drawing difficult.
- In design communication, shared-drawing space seems to be more important than eye contact.

These features are discussed and illustrated from the observations of the tutorial and the transcripts of the interview.

Visual feedback

The first study showed that drawing activities seem to be structured by the spatial relationships between the designer and visual feedback. One of the students described that he "found it very difficult to draw straight lines, and to draw accurately" with the stylus. And the tutor also noticed that "the pen in many ways is easier to use and the stylus was slightly difficult to control because I can't look down and up the screen at the same time." From experience and working with other design media, it can be seen that people prefer to sketch their design ideas with a pen. However, unlike the pen-based interaction (Study I), the interaction using a digitising tablet with a wireless stylus does not allow the visual feedback from the position of input. This feature makes people disconcerted because of the disassociation between using the pen in the hand and also having to look at the screen (Figure 3).



Figure.3

Eye contact versus the shared drawing space

Eye contact can improve the ability to communicate effectively between designers, but in design communication, the shared drawing space seems to be more important than eye contact. It is indicated that the students in on-line tutorial looked at the shared

drawing space mostly to take a sequence of the tutor's drawing action for the effective communication, although students could look at the tutor on the extra screen (Figure 4). According to one of the students, "I've certainly sat in face to face tutorials and not got into eye contact with the tutor for virtually the whole tutorial but I wouldn't consider that to be a problem. Because, I think in a tutorial, it's more about what's up here and what's on the paper and so that kind of communication is definitely more important than eye contact." For another student: "I don't think I have that much eye contact during the on-line tutorial and that wouldn't bother me. It wouldn't affect what I would say. So that certainly wouldn't be a problem not having the eye contact there."

For this on-line tutorial, however, all of the participants noticed that eye contact is also important between designers: "it's something that's very difficult to define, how you use it, but I think when you don't have it, you feel there's something missing." In addition, eye contact seems to be quite important in the design critique or presentation as well: "I find it very difficult to understand how I can make a presentation when I can't actually see."

In the meantime, several limitations were observed in use of on-line tutorial. But the main problems were mostly from the technical side, and they fall into two main categories: the EDB limitations and networks limitations.

DISCUSSION

These two studies, into the idea of remote design tutorial, explored various aspects of the collaborative design process and its supporting technology. These studies revealed a number of interesting issues, of which three are of special interests.

The first issue is how the media of IT, such as video conferencing might affect the nature of communication. Although a number of studies have been carried out focussing on the effects of information technology on the communication process (Gaver et al, 1993; Sellen, 1995), I focused on the effect of conversational behaviour in response to LANs such as time delay. The case studies indicate that the participants rely on intricate relations in time between design conversations. The time delay could interrupt the timing relations during the conversation between collaborators (Tatar et al, 1989). This suggests that this interruption could alter the way collaborators are thinking or at least talking. According to one of the students: "I am wanting to leap on but I haven't actually heard the reply yet, then it's kind of lost somewhere in the whole process." For another student: "I guess I just have to be more patient." In the on-line tutorials, telephones were also used for supplementing the digital audio. However, it seems that participants harmonise timing relations as like as in face-to face tutorials by the telephones because there is no time delay. The tutor has commented that "it was certainly easier by telephone because I was able to concentrate on what you were looking at."

The second issue is how IT media such as videoconferencing

might affect the design process and designs. Far from discovering these, it was discovered that IT could provide designers easy access to specialists such as engineers, acousticians and so on. As discussed earlier, efficient communication, such as the instantaneous interaction between designers in remote locations, does contribute towards establishing a rich and productive design environment. To this extent, IT helps designers have more opportunity to communicate with value engineers which they could not have in local otherwise. Consequently, IT may improve the quality of design work.

Effective design communications influence the quality of design in obvious ways. According to the tutor: "Effectively it [videoconferencing] would improve the design because otherwise you have to use somebody local and they're just not as good." However, "technology simply does not do that by itself." (Sanders, 1996)

Finally, what is the relationship between digital and manual media? I have attempted to address this relationship in the two studies. None the less, this still remains elusive and to be explored. It seems, however, that the relationship is neither a competition with each media nor replacements that will change the process of design and documentation. The relationship is but a complement that will continue to have a substantial impact on the each medium. This complement could present new opportunities for designers. The examples are a perspective drawing drawn by hand on top of the CAD generated images, a physical Renaissance architecture model cut directly from a CAD drawing using a computer controlled milling machine, a digital image generated from a scanned paper drawing and so on.

In addition, the process of design today seems to exist between the digital and manual working environments. Designers can choose flexibly between digital tools and manual tools in order to take advantages of the particular properties of each medium at a particular time.

CONCLUSION

This paper focused on the relationship between digital and manual media through the discussion of how manual media and IT using multimedia and the Internet can empower designers by providing them with new ways of working together. The studies revealed that digital and manual media should be used in a complementary way to aid the simulation of design projects and to serve as catalysts for design communications during all stages of the design process.

NOTES

1 The system (Figure 1) involves a large format computer display that seeks to integrate sketching with digital media. The screen display is projected onto the back of a glass drawing board surface, with a video camera mounted about the drawing surface for image capture. See Park(1996) for more details.

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