The Role of Sketches in Supporting Near-Synchronous Remote Communication in Computer Supported Collaborative Design

Phebe Mann[1] and Steve Garner[2]

[1] Institute of Educational Technology, The Open University Walton Hall, Milton Keynes, MK7 6AA, UK
p.mann@open.ac.uk
http://iet.open.ac.uk/people/index.cfm
[2] Department of Design and Innovation, Faculty of Technology, The Open University Walton Hall, Milton Keynes, MK7 6AA, UK
s.w.garner@open.ac.uk
http://design.open.ac.uk

Abstract. This paper presents recent research into the functions and value of sketch outputs during computer supported collaborative design. Sketches made primarily exploiting whiteboard technology are shown to support subjects engaged in remote collaborative design, particularly when constructed in 'near-synchronous' communication. The authors define near-synchronous communication and speculate that it is compatible with the reflective and iterative nature of design activity. There appears to be significant similarities between the making of sketches in near-synchronous remote collaborative design and those made on paper in more traditional face-to-face settings With the current increase in the use of computer supported collaborative working (CSCW) in undergraduate and postgraduate design education it is proposed that sketches and sketching can make important contributions to design learning in this context.

1 Introduction

Research studies of computer supported collaborative work (CSCW) have focused on either synchronous or asynchronous modes of communication (or both in some cases), but 'near-synchronous' working has received relatively little attention. Cross [1], Gabriel and Maher [2] and Peng [3] have carried out studies into collaborative design protocols. There have also been studies of argumentation and constructive interaction by Baker [4]. But very little is known about near-synchronous communication involving drawing and dialogue within collaborative design. Grinter and Palen [5] use the term 'near-synchronous' when they describe instant messaging. However, they provide no definition. We are using the term to refer to the use of communication tools in real-time environments where the participants experience or introduce short delays in exchanges. For example, participants engaged in instant messaging type messages in their own virtual space before they are sent to a shared text space. There are options for the senders to reflect on and change the message before sending it – to re-phrase

the wording, refrain from sending, revise the message after reading another participant's contributions etc. Similarly with drawn exchanges common in design collaboration; delays are created while sketches are constructed and considered. With text communication the messages are normally shorter than asynchronous exchanges (e.g. emails) and more closely represent dialogue. Another category of near-synchronous communication is the use of asynchronous media (e.g. emails within an e-conference) in a synchronous situation where all participants are simultaneously present. This allows threading and preservation of discussion, hence, messages can be organised as discussions.

Near-synchronous communication includes the use of technology by participants to deliberately withhold or delay some communication in an otherwise synchronous exchange of communications. For example, the making and improvement of sketches in a 'private' space (such as on paper or on a whiteboard) before the results are published to the other participants engaged in real-time collaborative working. Thus the state of participants' work is not revealed to partners until the originator wishes it. One aim of this paper is to present a case for viewing near-synchronous communication as important to design team working - particularly for student designers. While reference is made to verbal and written communication the focus here is on the use and value of sketch outputs within near-synchronous communication in design. It is suggested that graphical communication can play a role in encouraging, creative, rhetorical and critical exchange of ideas, supporting teams to build on contributions of individuals. Graphical communication is here taken to include a wide range of representations such as drawings, diagrams, images and their associated annotations but of primary interest is freehand sketching. Such graphic communication may have a particular and important value for designers.

2 Issues of Methodology

The objective of the study was to gather information on computer supported collaborative design via observation of, and interviews with participants. The authors sought to understand how the research subjects made use of a shared environment, including a shared whiteboard and audio conferencing, particularly the exploitation of sketching in near-synchronous communication.

This study was made using different groups of students of design as subjects. Some groups were drawn from the Bartlett School of Architecture, University College London. These volunteers had up to two years professional experience in design for the built environment. Their professional training included the use of Computer Aided Design (CAD) tools. Other subjects were mature Open University students who, while perhaps being novices in design, presented wide-ranging skills and considerable experience of collaborative working in industry and commerce. These distance learning students possessed a minimum of one year of degree studies in an Open University design course. They were recruited from Open University students who choose the CAD/CSCW workshop at a residential school. The participants were broadly computer literate and keen to take part in computer mediated communication (CMC).

In a field such as design research, where there are various opinions about appropriate research methods, a qualitative approach was deemed necessary. A popular and successful approach applied to the study of design activity has been 'thinking aloud' and 'drawing aloud' protocol analysis. It was decided that such an approach would provide useful triangulation with which to determine the strength of findings from other research tools. Garcia and Jacobs [6] applied a conversation analysis approach in their study. They examined the nature of discourse within CMC in a naturalistic environment. Their subjects were observed, and their conversations recorded, during the completion of a realistic task. Conversational analysis takes into account turn-taking, sequential and repair organisation and turn construction design. They found conversation analysis to be a useful tool for studying CMC. Their ideas assisted the construction of this research and their findings assisted the consideration of system requirements.

3 The Study, *Lyceum* and the Generation of Data

The data were collected at the Bartlett Faculty of Environment, School of Architecture, University College London and the Open University T302 'Design and Innovation' residential schools held at Bath University (July/August 2004). A questionnaire on the subjects experience, background and familiarity with computing was used at the beginning of each study.

The study of the architectural students and the Open University students consisted of three and two sessions respectively, with groups of 3 or 4 participants. Each session was conducted in four parts. The first part provided an introduction to the CSCW tools including *Lyceum*, the conferencing environment. The second part provided hands-on structured training of 30 minutes using the *Lyceum* shared whiteboard, text chat and audio conferencing facilities. In the third part, the participants were engaged in a collaborative design task using *Lyceum* and where the object was the design of a wine rack (duration approximately 40 minutes). Finally, the designers participated in a semi-structured evaluative discussion of their experience, guided by the researcher.

The participants were located in adjacent rooms in order to simulate remoteness in the collaborative design task. Each participant had access to a tablet PC, with quality headphones and microphone. Each tablet PC was installed with *Lyceum* and was connected to a local server and other tablet PCs via a wireless network.

The data generated by both studies included the interaction displayed on the shared whiteboard, audio recordings of dialogues captured using *Lyceum*, continual sequential screen images captured via *Screencorder*, and videotape of the participants during the studies.

Lyceum is a software package developed at the Open University (see Buckingham-Shum *et al*., [7]) to support its students in remote working and learning. It presents functionality to support remote collaborative working which is used by some courses to enrich distance learning. Some of the facilities of *Lyceum* used in this study are:

• A shared ‘Whiteboard’, designed to support freehand sketch representations (Figure 1) and which presents a range of facilities for freeform and predefined shapes, text, colour, order, resize etc.

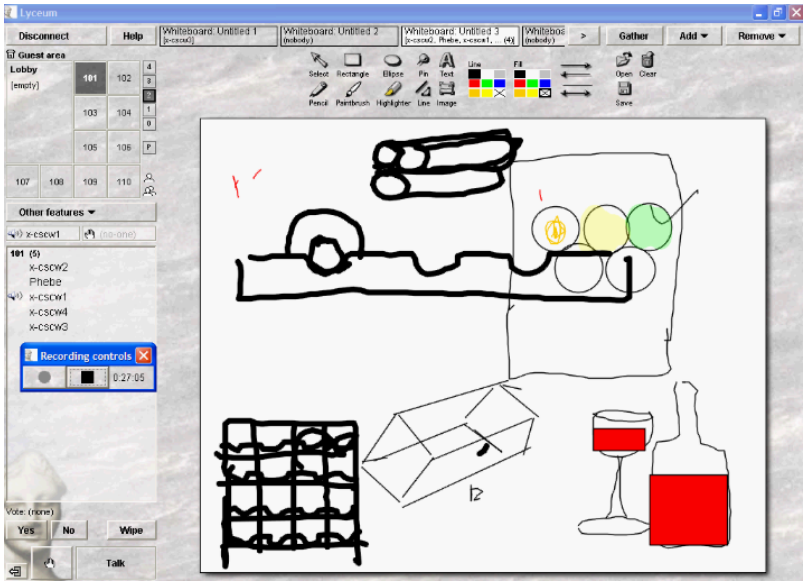

Figure 1 Screen shot of *Lyceum* whiteboard showing sketch representations made during collaborative design

• A ‘Talk’ facility for audio discussion. On logging onto the *Lyceum* server, participants can see the names of others present in the initial Common Room. The Talk button activates the microphone for speaking and this is relayed to everyone in the virtual room. There are minimal technical constraints imposed on floor control. Any participants can speak at any time. In *Lyceum*, the participants manage by social agreement, learning the art of turn-taking; this maximizes the flexibility for different kinds of meeting. Interactional fluidity is a key skill that *Lyceum* users learn.

• ‘ScreenGrabber’ supports the sharing of *ad hoc* material from any digital source - web sites, CD-ROMS, etc. It allows a captured screen dump to be shared and enables participants to display materials for discussion, or make a point.

The captured dialogue was subjected to conversation analysis along the lines described by Suchman [8]. It sought to identify, amongst other things, evidence of recurring activities across the various collaborative design sessions. Also there was a review of the sequential screen capture files together with their respective audio recording of the collaborative design sessions. Clearly it was necessary to distinguish who spoke what and when, and who drew what. This necessitated synchronising the

graphic files and the dialogue files. Transcripts of the verbal dialogues were compiled and descriptions of actions during the collaborative design were constructed. The dialogue transcripts and the description of the actions sessions were then examined using QSR NVivo2 (QSR International Pty Ltd. *http://www.qsrinternational.com /products/productoverview/product_overview.htm*) which facilitates the handling of rich data records of text, images and sound. Nodes, annotations and codes were used. Video tapes were reviewed to countercheck with the sequential screen capture and audio recording. Selected sections of the transcripts were annotated with action descriptions.

Table 1. Example of data collection and analysis (collected 13.7.04). Relevant concepts appear in italics. 1, 2, 3 and 4 are anonymous participants

Time stamp	Drawing and dialogue	Analysis
26:18	1: Do you see the image I have drawn in the *bottom left hand corner*, which is basic… the basic structure put together, and it shows the part for the bottle to go in, again it is supposed to stop the bottles coming forward and falling out. [*1 draws his idea in the middle of the screen*]	[2 and 3 talked simultaneously, can't hear 2 clearly to record] 1 starts with his "private *space*" when he draws at the bottom left hand corner of the whiteboard. 1 considers using the "*public" space* when he draws in the middle of the screen.
27:05	1: Do you see what I mean?	- *breadth-first process* where designers consider different ideas first.
27:06	2: Do we need that if we *tip the whole rack slightly backward* so that the bottles are held by the tubes, *do we need to support it?*	- *many imaginative and creative alternatives emerging in sketches*
27:26	1: No I don't think so, the only thing is it probably needs a net at the bottom of the cradle	
27:41	2: Ok, where has everyone gone? 3: Sorry I have wandered away a bit and I couldn't find my way back again.	[they have gone to Room 102 without announcing their whereabouts]
27:49	3: There are loads of whiteboards in this room.	The participants have not got the concept that when one of them removes a whiteboard, this affects everybody, all the data on that whiteboard will be gone forever.
27:54	[each starts removing whiteboard] [each person creates a new whiteboard to sketch their ideas]	

4 Discussion

Each group of participants generated a range of concept proposals. Some of these proposals underwent development during extended periods of verbal and graphic communication by the participants. Other concepts were fleeting – perhaps consisting of one sketch or verbalised idea from one participant. As earlier studies have found (see Garner [9]) there was considerable difference in the extent of marks used to construct some images.

Some participants defined their own drawing areas using the functionality of the whiteboard tool but there was limited facility for a truly private drawing space other than paper on each individuals desk. Schön [10] [11] has carried out protocol studies on individual designers working on architecture layout problems. In his findings he identifies designers' ability to hold a 'reflective conversation' – a personal discursive reflection using graphical representations to stimulate evaluation and creative thought. He notes "a designer sees, moves and sees again... the designer sees what is there in some representation of a site, draws in relation to it, and sees what he/she has drawn, thereby informing further drawing." It seems likely that students without a developed ability for sketching or without developed design knowledge may need, as Schön suggests, a personal 'reflective conversation' space where they can externalise, reflect, edit and develop their own thinking prior to communicating conjecture to the group. Expert designers would probably be more comfortable sharing early ideas and would probably resent the additional time and effort involved in using such a private space.

Interestingly, in these two studies, mapping the dialogue together with the output of the graphic representations reveals that the generation of new ideas was not evenly distributed over the period of the study. There were clear creative phases. When the new ideas were plotted they appeared not to coincide with periods of intense synchronous verbal communication, nor did they appear immediately after one of the many long breaks in communication. It appears that creative group behaviour is somehow associated with near-synchronous communication.

Figure 2 is a screenshot of a whiteboard produced by a team of architecture students. It presents four different proposals. Each proposal is mostly the work of one individual with some contributions by other participants. The concept in the lower right quarter was the most favoured concept for development.

Figure 3 shows part of this development. It reveals both a simplification of the design (right sketch) and a reinterpretation as a more complex concept (left sketch).

Figure 4 was produced by an Open University group and reveals variation within one concept ranging from a geometric design (top right) to one representing a bunch of grapes (centre right).

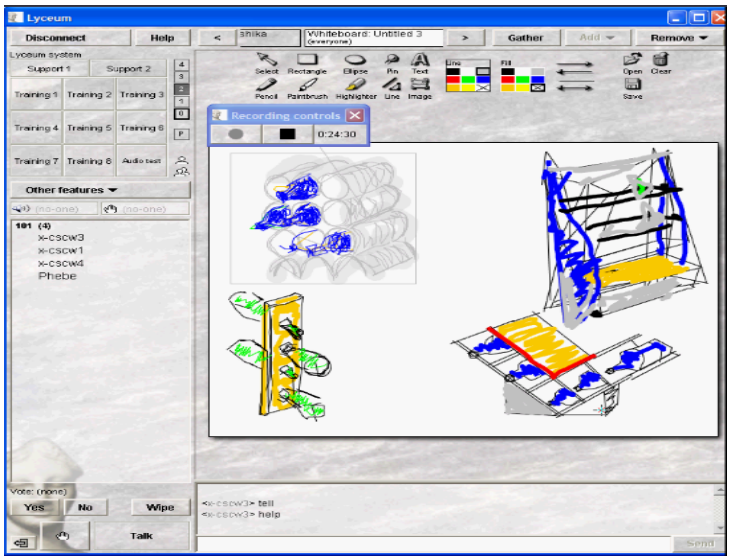

Figure 2 Whiteboard output from one subject group (wine rack design task)

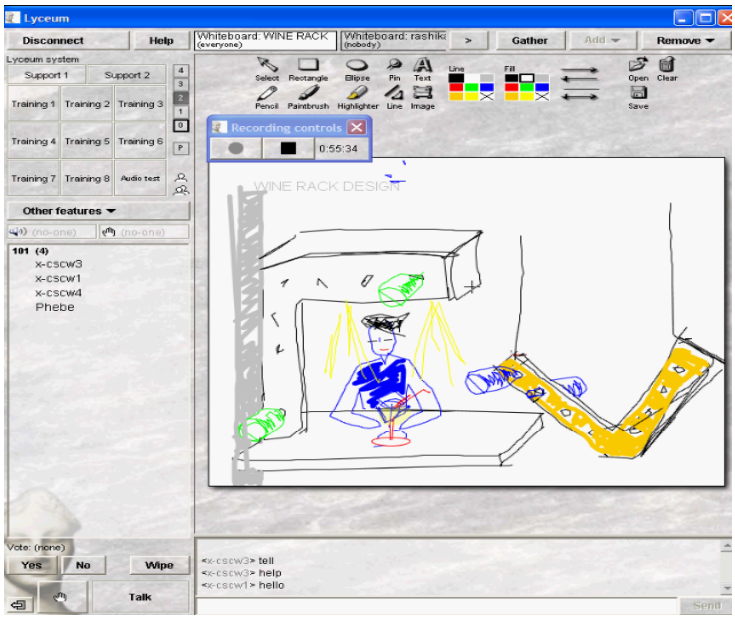

Figure 3 Later development by the group illustrated in Figure 2

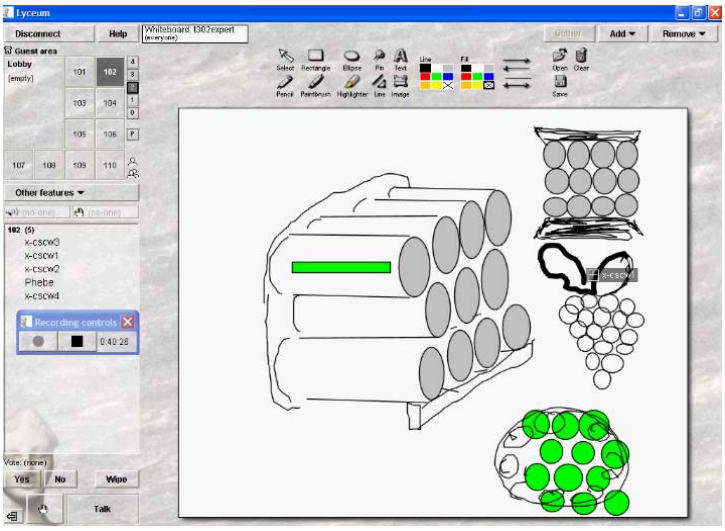

Figure 4 Whiteboard output from another group of subjects

The establishment of a shared understanding or grounding appears crucial for successful designing and much of the communication, both verbal and visual, was used for this purpose. As suggested by Dillenbourg and Traum [12] a whiteboard enables research subjects to make sketches that clarify ideas that otherwise might be difficult to turn into words and their work suggests that the graphical features of a whiteboard are less important than its capacity for persistence – the ability to display visual data throughout collaborative design. They conclude that continuous shared visibility of a whiteboard plays a key role in supporting grounding. In our situation of collaborative designing, the verbal dialogues made considerable reference to the content of the whiteboard. Post-study interview feedback suggested that the whiteboard had indeed assisted verbal communication and the establishment of shared understandings.

5 Conclusions: Supporting Remote Design Collaboration

In this study the subjects had little access to private virtual spaces to explore and experiment with ideas. All computer based sketch output was made on the whiteboard and thus it was in the public domain. Verbal feedback and evidence of private work on paper suggests an important need for supporting private drawing. Having said this there is an issue in whether it is appropriate to support 'private' design work within the context of CSCW. There have been studies of remote and face-to-face collaborative design that reveal the importance of incompleteness or ambiguity - particularly pictorial ambiguity - as a catalyst for creative thinking by other members of a design team as well as by the originator. Further investigation is required here.

While ‘think aloud’ and ‘draw aloud’ protocols were successfully used to generate data there were some long gaps without verbal and graphical communication. As found in other studies, the workspace tools should support the mechanisms of communication and mediate interactions between drawing and dialogue and the tools should facilitate designers’ coordinating their communication. Collaborative tools should enable the sharing of a common orientation and mutual understanding, yet still allow some means of distinguishing between individuals. The data also revealed that it is important that all collaborative designers should be allowed to access shared objects, including moving and editing them. For an interactive system supporting collaborative design, the ‘presence’ of the participants should be represented in the tools - even where an individual is not always involved.

In this research the data suggests that tentative design suggestions can take graphic or spoken form. However, when other participants see an image of a suggestion on the shared whiteboard it carries greater weight or possesses more impact than verbal suggestions (probably compounding the tacit reluctance to share early ideas). Suggestions presented graphically (often together with verbal reinforcement) possess much greater persistence and they are more often found in the final proposal than suggestions made only verbally. It is important that the drawing and dialogue interactions are understood by collaborators, as some participants reveal a preference for sketching or discourse.

Many earlier studies of CSCW have sought to identify system requirements for the support of collaborative designing. This study suggests that those engaged in design activity may need facility for near-synchronous communication in addition to access to conventional tools for supporting synchronous and asynchronous communication. Near synchronous communication presents oportunity for reflection. It allows drawings to be constructed without pressure for explanation from those viewing. It allows ideas to be recomposed. Unlike verbal dialogue the interplay between design participants using sketches to augment communication is slow. There is also a need for interpretation and reflection on outputs before a response can be made. Face-to-face collaborative design reveals considerable use of near-synchronous communication. Perhaps new systems for collaborative design need to reflect this.

A number of researchers have pointed out differences between design students engaged in CSCW and design professionals. Finger *et al* [13] highlights students lack of domain knowledge and design process knowledge and it is clear that one of the key reasons students are given design tasks is to develop these knowledge and skills. While they may seek a high quality output students are also conscious of grades and other assessments and the demonstration of learning outcomes set by tutors. Professional designers are concerned far more with the quality of the resulting output. For student designers the use of sketching may provide an important means of supporting communication, developing a shared understanding of tasks and problems, sharing conjecture, co-constructing proposals and reflecting on achievements. Thus tools for the support of student designers engaged in CSCW may have to differ from tools intended to support professional designers in CSCW. As Artman & Ramberg *et al* [14] confirm there is a vital role for sketching in maintaining collaborative working. Perhaps there may be a significantly greater need for novice designers to oscillate between what they call ‘different forms of design contexts’.

Acknowledgements

Our thanks to the students of the Open University T302 course and the graduate students of Bartlett School of Architecture, University College London for participating. Our thanks also to Prof Alan Penn, Lesley Gavin, Georgina Holden and Miquel Prats.

References

1. Cross, N., Teamwork in Design. In: Maher, M. L., Gero, J S, Sudweeks, F (eds): Formal Aspects of Collaborative CAD, Key Centre of Design Computing, Univ. of Sydney, Australia, (1997), 145-164
2. Gabriel, G.C., Maher, M.L., Coding and Modelling Communication in Architectural Collaborative Design. In: Ataman, O., Bermudez, J., (eds) ACADIA '99, Salt Lake City, (1999)
3. Peng, C,. Exploring communication in collaborative design: co-operative architectural modelling, Design Studies, 15(1), (1994), 19-44
4. Baker, M., Argumentation and constructive interaction. In: Coirier, P., and Andriessen, J., (eds) Foundations of Argumentative Text Processing, Amsterdam: Amsterdam Univ. Press, (1999), 179-202
5. Grinter, R.E. Palen L., Instant messaging in teen life. ACM 2002, Conference on Computer Supported Cooperative Work (CSCW2002), Nov 16-20, New Orleans, LA. NY ACM Press (2002), 21-30
6. Garcia, A. C., Jacobs, J. B., The eyes of the beholder: Understanding the turn-taking system in quasi-synchronous computer-mediated communication. Research on Language and Social Interaction, 32(4)**,** (1999), 337-367
7. Buckingham-Shum, S., Marshall, S., Brier, J., Evans, T., The Lyceum Internet Voice Groupware system: technical design, implementation and deployment of distance learning. In: Euro-CSCL 2001, Maastricht, Holland (2001)
8. Suchman, L., Qualitative Analyses of Collaborative Practice. In: Proc. of Technology and Cooperative Work, Tucson (1988), 1-9
9. Garner, S., Comparing graphic actions between remote and proximal design teams. Design Studies, 22(4), (2001), 365-376
10. Schön, D. A., Designing as reflective conversation with the materials of a design situation. In: Knowledge-Based Systems, 5, (1992), 3-14
11. Schön, D. A., Designing: Rules, types and worlds, Design Studies, 9(3), (1988) 181-190
12. Dillenbourg, P., Traum, D., Does a shared screen make a shared solution? In: Hoadley, C., Roschelle, J (eds), Computer Supported Collaborative Learning (CSCL'99). Stanford Univ. Palo Alto, California. Mahwah, NJ: Lawrence Erlbaum Associates, (1999)
13. Finger, S., Gelman, D., Fay, A., Szczerban, M., Supporting Collaborative Learning in Engineering Design. In: Shen, W., *et al* (eds), Proc of 9th Int. Conference on Computer Supported Cooperative Work in Design. Coventry Univ., UK, (2005), 990-995
14. Artman, H., Ramberg, R., Sundholm., Cerratto-Pargman, T., Action context and target context representations: A case study on collaborative design learning. In: Proc. of Computer Supported Collaborative Learning, Univ. of Taiwan, Taipei, (2005)