DESIGN COMMUNICATION: ISSUES CONFRONTING BOTH CO-LOCATED AND VIRTUAL TEAMS

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Today's design activities are usually conducted in teams of professionals who represent different design domains, e.g. architects and engineers. . Within these teams clear and accurate communication of design and technical concepts and information is critical. A current trend is for the conduct and management of these teams to move towards working more in virtual environments. The use of high bandwidth Information and Communication Technologies (ICT's) is increasing and with this increase is the need to better understand those generic skills, such as communication, which contribute to the successful application of the ICT hardware and software. Communication skills have been identified as an important factor which may be affected in the transition from co-located team collaboration to the virtual environment. These issues usually manifest themselves in the ability of team members to use both visual and verbal forms of communication concurrently. Also of significance is the importance of "cues" in communication interactions during collaboration, this resulting in less effective achievement of shared understanding among team members. This paper reports on industry based research of both co-located and virtual teams involved in the activity of designing. It concentrates on the communication between team members. The results of this research identify a range of communication issues which confront these teams in their design activities which will inform, in association with other factors being researched, which are outside the scope of this paper, the development of skills auditing and mapping tools.

Keywords: communication, design process, interaction, virtual teams

INTRODUCTION

The use of teams for both the design and management of projects has long been used by the construction industry. However, with a growing trend towards globalisation, with designers and managers being involved in international projects, there is an inevitable move away from traditional co-located teaming to 'virtual' teaming. The concept of virtual teaming does appear to provide a number of answers to the problematic issues associated with collaborating over distance. Nevertheless, literature indicates that there are some aspects, regarding the application of ICTs, that require better understanding and application.

This paper reports on the interim findings of an on-going research project investigating the core skills of team participants involved in early phase design of

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construction projects. The focus of the study is on the identification of the skills and practices that will best support the effective and efficient adoption and application of the virtual environment to the practice of team design. The element of the research upon which this paper concentrates is the measurement and evaluation of design team interactions.

VIRTUAL TEAMING

The use of teams in the construction industry is fundamental, with these teams being described as a cluster of two or more people usually occupying different roles and skill levels that interact, '*…adaptively, interdependently, and dynamically towards a common and valued goal*'(Salas et al 2000: 341). Such teams provide the vehicle for the process of collaboration (Beyerlein et al 2003). The use of teams with a diverse mix of professionals (i.e. designers, engineers, surveyors, contractors), with a range of backgrounds and experiences, has long been recognised as requiring good management and facilitation to achieve successful outcomes. The introduction of a range of technological options and media for the support of these teams has contributed to the development of a range of types that teams may take. With the adoption of new technology to the team process there has been the development of a range of forms of these teams, McDonough III et al (2001) provide the following summary of types of teams:

- **Co-located -** comprising individuals who work together in the same physical location and are culturally similar. As members must be actually interacting when collaborating this refers to a face-to-face situation.
- **Virtual -** comprising individuals who have a moderate level of physical proximity and are culturally similar, e.g. team members who are in the same building but on different floors.
- **Global -** comprising individuals who work and live in different countries and are culturally diverse

There has been a move from co-located teams towards more virtual and global teams. Clients are increasingly demanding higher quality and efficiency from their design and construction service providers, thus prompting teams to be assembled from more diverse geographical locations (Kimble et al 2000).

COMMUNICATION DURING DESIGN COLLABORATION

Within the context of a team involved in producing a design a key criterion for a successful outcome is their ability to communicate effectively. According to Chiu (2002: 189) communication is, '*…the dynamic process in which one person consciously or unconsciously affects the cognition of another through materials or agencies in symbolic ways'*. There are many tools which may be used to communicate ideas and information. Whilst a significant proportion of design team communication is likely to be facilitated by speech and text, other communication techniques adopted include:

- **Artifacts:** the simplest type of communication, which *'…allow the externalization and representation of objects, constraints, form, function, assembly, materials,*

and so on'(Perry and Sanderson 1998: 275). They include such things as models or CAD visuals.

- **Drawings:** Drawings can bridge differences between disciplines and professional jargon (Laseau 2001). Importantly drawing can be in a range of forms from impromptu sketches to complex and detailed technical drawings.
- **Gestures:** The use of movement of parts of the body, predominantly the hands, to provide a physical analogy of shape or movement (Williams and Cowdroy 2002)

The design team context is a dynamic environment which requires participants to have access to the full range of verbal, textual and visual mediums for successful design collaboration.

COMMUNICATION IN A VIRTUAL TEAM

The increase in globalisation in business activities, fuelling a trend towards the use of the virtual team environment, adds a new dimension to their operational characteristics. Co-located teams are always synchronous, whilst virtual teams can be both synchronous and asynchronous. Virtual team members may discuss a project in real time (i.e. via video conferencing and web chat programs), however at this stage of new technology adoption the majority of communications involve email or electronic bulletin boards with delays between giving and receiving communication (Maher et al 2000). Table 1, adapted from Maher et al (2000), portrays each of the most common forms of co-located and virtual team communication.

Table 1: Communication options for teams including temporal aspects (adapted from Maher et al 2000).

Type of communication	Temporal aspect	Media
Email	Asynchronous	Text, Data files
List serves	Asynchronous	Text, Data files
Bulletin boards	Asynchronous	Text, Data files
Talk, chat	Synchronous	Text
Broadcast	Synchronous	Video, Audio
Video conferencing	Synchronous	Video, Audio, Images, Text
Face-to-Face (Co-located)	Synchronous	All

The table above serves to illustrate the varied communication options and capabilities which are available to design team collaborators. Naturally there are both advantages and challenges associated with these options and capabilities.

One of the major objectives of the research project being conducted is to determine whether communication techniques used in a co-located setting translate effectively and efficiently into a virtual setting. For example, when communication is facilitated using a teleconference, research has shown that this method can result in a reduction of social interactions between team members (Gabriel and Maher 1999) and difficulties in sharing visual information (Gabriel and Maher 1999; May and Carter 2001; Poltrock and Engelbeck 1999). The most prominent area of concern is the use of non-verbal cues in virtual environments. Even when interacting using visual capabilities (i.e. video conference or web cameras) the ability to communicate using non-verbal interactions (body language) can be inhibited (Hoyt 2000). However, the use of technology can hold some advantages when communicating over distance. These technologies often allow more focused and concise information exchange

between team members (Gabriel and Maher 1999; Maher et al 2000), and assist team members adherence to their task (Cleland and Ireland 2002).

EVALUATING DESIGN TEAM INTERACTION

Having identified issues relating to the operation of design teams the next step is to consider how designers interact. A method of evaluating such interactions is now presented.

Bales's Interaction Process Analysis (IPA)

Bales's Interaction Process Analysis (IPA) is used to understand the interactions of a group of people engaged in a task. It is a '*…method of classifying direct, face-to-face interaction*' (Bales 1951: 5) and is an attempt to generate a set of categories which are generic in nature to represent team/human interaction (Bales 1951). The IPA system allows for the analysis of both verbal (speech) and non-verbal (gesture) interactions. As Bales (1951: 31) explains, '*The observation of social interaction and its situation is the common starting ground for all of the social sciences'*. Bales's categories, as illustrated in Figure 1, are exhaustive in terms of team interactions. Note that the key describes where within the analysis different concepts can be measured including communication and decision making.

Although IPA has been used primarily to study co-located construction team interactions (Gameson 1992; Wallace 1987), there have been a number of studies which have utilised the system to investigate Computer Mediated Communication (CMC). A list of some of these studies is shown in Table 2 including a summary of their major findings.

Table 2: Authors and major findings of studies which have used Bales's IPA to investigate Computer Mediated Communication (CMC)

Authors	Major Findings
Hiltz and Turoff (1993)	Differences on the 'agreement' and 'disagreement' categories
Jaffe et al (1995)	Masking one's identity in CMC resulted in more uninhibited interaction
Chou (2002)	More socio-emotional (SE) interactions occur in synchronous CMC when compared with asynchronous CMC. There was an increase in one way communication in the asynchronous mode when compared with the synchronous CMC. There were gender interaction differences which saw females engaged in SE more often than males in both forms of CMC.
Gorse and Emmitt (2003)	Lack of Socio-Emotional (SE) interaction between construction partners and the majority of their interaction was task orientated
Pena (2004)	During video game communication there was a higher rate of socio-emotive interaction compared with task orientated

A number of these studies were forced to add new categories to their coding systems to account for new concepts introduced because of the use of CMC's. For the purposes of this paper the original Bales 12 categories of interactions have been used. Rather than revise the Bales system additional coding systems, such as 'communication techniques', were developed to measure other aspects of communication. However, presentation and discussion of these is beyond the scope of this paper and will be reported in other publications.

RESEARCH METHODOLOGY

Having reviewed the literature, and developed a theoretical foundation for the research, the next stage was to conduct a 'test' using real-word data. Aspects of the preliminary data collection and analysis phase of the project are now described. The research method received approval from relevant University ethics committees before data collection commenced.

Participants

Participation in the investigation was restricted to research partners of the Cooperative Research Centre for Construction Innovation [CRC-CI]; as such participants were sourced from a project architectural firm. This firm was multi-national with offices in Sydney and Melbourne, as well as other Australian state capital cities, and multiple offices in Asia and Europe. The participants were involved in an architectural design team.

The participants were randomly chosen from design staff based on their relative availability. They were of a diversity of gender, age and degree of experience and influence (power), representing higher management to junior staff (Marchman III 1998). In total five participants agreed to take part in the study. Three were videoed participating in co-located activities and two in virtual activities.

Materials

Digital video recording was used as the method of data collection. . The advantages of video recording participants include the ability to review interactions and behaviours, as well as the ability to compare different coders' or viewers' interpretations. In addition video recordings can become a replacement for live observation (Guerlain et al 2004).

The physical technical setup included:

- Cameras, two of which were used during the co-located stage to monitor actual design activity and the designers. Only one camera was used in the virtual stage because direct streaming (and recording) was used to record the design activity from the computer/whiteboard.
- A removable hard-disk which allowed easy transport and manoeuvring between research locations.
- Tie-clasp microphones which were used to record audio in an unobtrusive manner.

Procedure

Participants used two different levels of bandwidth (co-located and virtual) or operational modes so that any differences in interactions used between them could be observed. The two levels were:

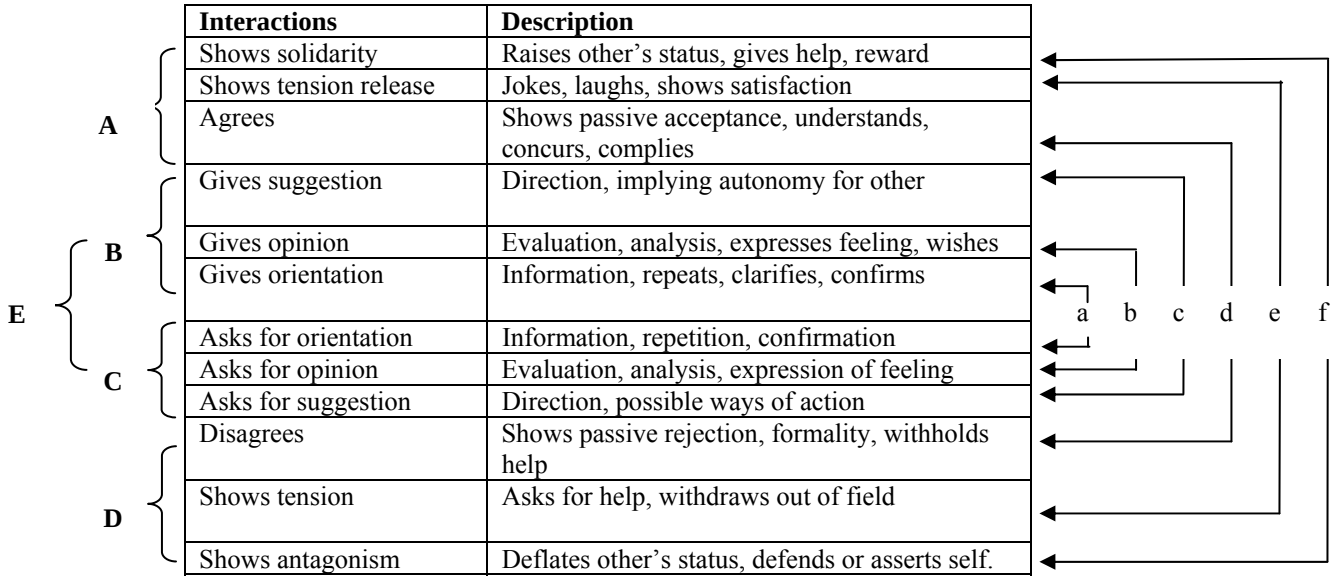
- Traditional collaborative design: using the communication and design tools currently being employed by those co-located design team members. These included simple face-to-face (F2F) interactions such as talking and sketching.
- Virtual collaborative design: using a shared Electronic Whiteboard (EW) which allowed users at remote locations to view shared drawings, images and text synchronously. Also included were synchronous speech and visual communication which was facilitated using a web camera.

While co-located participants were familiar with their surroundings and the techniques involved in the collaborative design sessions, the virtual participants needed to be trained and familiarised with the functions and use of their new collaborative computer software. Before each design session the research team spent approximately half an hour familiarising participants with the technology.

Once participants were familiar with the software, they took part in the design sessions. No briefing on the architectural project was provided and each participant was asked to discuss and share the architectural aspects of a design they were working on with the other participant also working on the same project. The two sessions were each approximately 30 minutes in length.

Once the design sessions had been videoed they were formatted into MPEG-4 files and the data was coded using ethnographic software: Noldus Observer Pro. This software is a *'…manual event recorder for the collection, management, analysis and presentation of observational data*' (Burfield et al 2003: 21). It allows researchers to view live or recorded video data, and score the frequency of specific behaviours, as well as how these behaviours interact with each other or with independent variables. The coding of the traditional and virtual design team data was based on the Bales IPA coding scheme shown in Figure 1. For each session (co-located and virtual), the coder recorded the participants and their interactions.

Figure 1: Figure showing those interactions present within teams and their description [adapted from Bales (1951)].



	Interactions	Description
A	Shows solidarity	Raises other's status, gives help, reward
	Shows tension release	Jokes, laughs, shows satisfaction
	Agrees	Shows passive acceptance, understands, concurs, complies
B	Gives suggestion	Direction, implying autonomy for other
	Gives opinion	Evaluation, analysis, expresses feeling, wishes
	Gives orientation	Information, repeats, clarifies, confirms
C	Asks for orientation	Information, repetition, confirmation
	Asks for opinion	Evaluation, analysis, expression of feeling
	Asks for suggestion	Direction, possible ways of action
D	Disagrees	Shows passive rejection, formality, withholds help
	Shows tension	Asks for help, withdraws out of field
	Shows antagonism	Deflates other's status, defends or asserts self.

RESULTS AND DISCUSSION

The analysis of the videoed design sessions using Bales's IPA provides results to inform the future investigation of interactions within collaborative design teams. The results below will be used to be inform conclusions as to how interactions may differ between the two operational states: co-located and virtual.

A chi square analysis was conducted to determine whether there was a 'good fit' (Howell 1997) between the data one would expect for design collaboration (co-located) and the data for the virtual design team collaboration. The Monte Carlo exact test was used as there were variables which had a cell count of less than five. Table 3 shows that the Monte Carlo Chi squared test indicates significance χ^2 (11, N = 370) = 21.401, p = .016 showing a difference exists between the interactions of those collaborating in a co-located environment when compared with a virtual environment.

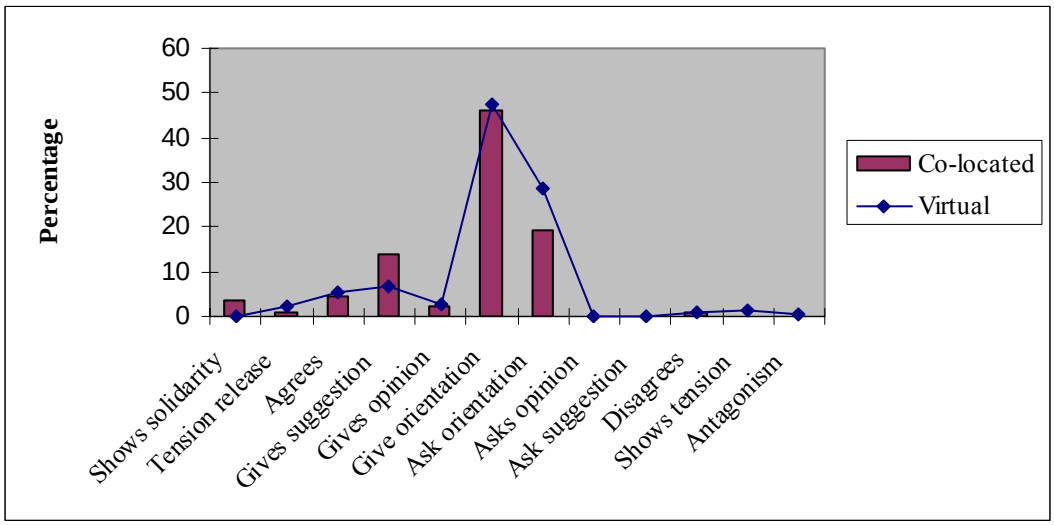
Table 3: Results of Chi Square test, displaying results for Monte Carlo exact test.

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)
Pearson Chi-Square	21.401(a)	11	.029	.016
Likelihood Ratio	25.379	11	.008	.013
Fisher's Exact Test	21.118			.016
N of Valid Cases	370			

(a) 13 cells (54.2%) have expected count less than 5. The minimum expected count is 0.48.

Figure 2 compares the percentages of occurrence (vertical axis) of the IPA categories (horizontal axis) in the two design sessions and illustrates where some possible areas of difference may lie. As a percentage of total interactions, the co-located collaborators used proportionally more of the 'Gives Suggestion' category than the virtual team. The opposite is true for the 'Asks Orientation' category.

Figure 2: Graph indicating the percentages of interactions for each category of the Bales's IPA for the co-located and virtual operational conditions



Some reasons hypothesised, based upon literature reviewed, (Hiltz and Turoff 1982), regarding these two areas of difference may be:

- 'Gives Suggestion': Its increased use in face-to-face collaboration could be a result of the ease of contributing and 'firing off' suggestions and ideas in a co-located 'brain storming' situation compared with EW condition where it is much more involved to spontaneously contribute to team discussion.

- 'Asks Orientation': Its greater use may be due to difficulty in establishing orientation in attempting to share an understanding of the design. This would naturally lead to a higher proportion of questions relating to the design for the EW compared to the face-to-face conditions.

CONCLUSIONS

Having looked at relevant literature to understand theory, determined a system for analysing interaction (Bales's IPA) and then conducting a data collection and analysis test, this paper concludes that there are significant challenges for professionals working on designs as members of both co-located and virtual teams. The analysis of data collected to date shows that the nature of the interaction process between designers differs between 'traditional' and 'virtual' conditions. It is therefore essential that designers understand the characteristics of the different environments in which they may find themselves working. This raises issues of whether they possess the necessary skills to function efficiently and effectively, particularly in virtual, high-bandwidth technological, environments. The final outcome of the research, following the analysis of more observational data, is to develop skills mapping and auditing tools to assist individual design professionals and design teams working in virtual environments.

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