Gains and losses of information when collaborating remotely over a network communication in the construction industry

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Abstract
The AEC industry traditionally has a high degree of organisational fragmentation so that on any one scheme, there are typically multiple organisations who come together and have to collaborate to deliver the end product. Additionally, there is an increasing trend towards the partners on a scheme being based in several countries. Thus, the industry creates a significant need for collaboration between remotely situated people. Traditionally this has been met either by collocation or having meetings to which people travel. Collocation is expensive and disruptive and takes people away from their colleagues, family and support systems. Meetings are likewise expensive and considerable amounts of time can be wasted travelling. There has therefore been a growing trend for people to collaborate over a network using a variety of tools. At the lowest level, this involves using email which is very restrictive. More recently with higher bandwidths becoming common place, the adoption of relatively sophisticated collaboration systems has become more common. These typically allow features such as desktop sharing, chat, audio and visual communication and recording the session. It is generally accepted that human communication is typically only about 50% verbal and the rest is things such as body language, gestures etc and hence any remote collaboration is bound to be less satisfactory than a face to face meeting. The authors have set out to try and examine how well remote communication works for typical engineering design tasks. The work started with an examination of some of the available software tools and was then followed by a series of experiments in which candidates undertook various design tasks using collaboration software. To provide a comparison, a series of identical tasks were also undertaken by participants working face-to-face. The sessions were undertaken in purpose built laboratories that allowed the full recording of the events. The results were carefully analysed using various metrics which measure time spent on social activities, technical activities, decision making etc. Also the time spent on the various activities was measured. The results are interesting in that they show for some of the experiments that for technical tasks, working over a network can actually increase the efficiency of the process.

Keywords: construction, collaboration, communication, remote, network

1 Introduction
This research study explores the impact of emerging communication technologies on small group performance when undertaking a design task. Understanding the interaction between the two communication technology such as face-to-face (FTF) and computer-mediated communication (CMC) is a key factor in improving the construction project communication. No previous work has
been done to understand the impact of modern communication technologies on performance of construction groups during design process. In addition, no efforts have been made to identify the characteristics of communication technologies that have been the greatest impact to construction project communication. Communication plays a critical role in project success. Many industry professionals and researchers have cited communication as the most single important factor affecting project performance (Thomas, 1998). Previous research by McGrath (1994) indicates that the main gains in utilizing computer supported communication come from three sources: 1) overcoming the time and space restrictions for conventional face-to-face communication, 2) improving the group performance through altering the communication process, and 3) Increasing the value of information through better accessibility and processing capabilities of computers (McGrath, 1994).

This study compares the use of FTF and CMC in coordination meetings using a research framework called TEAM Interaction Analysis (TEAM-IA) framework (Kathleen, 2007). This multi-methodological empirical-based framework provides an accurate analysis of meeting activities from four perspectives: Team interactions, Emotional interactions, Artefact interactions, and Model interactions. An observation results from the experiment will be analysed using TEAM-IA framework. The observations included video and audio recording and satisfaction questionnaire.

2 Research design and methodology

Today, there are many learning management systems employed by businesses and educational establishments that allow users to sign on as course administrators, run discussions, and upload materials, along with multimedia components for meetings to use. As shown in Figure 1, Macromedia Breeze (now known as Adobe Acrobat Connect) provides an interface for synchronous and asynchronous learning, including online video conferencing events into which one can import sound, animations, video, presentations with voice narration, interactive quizzes, and threaded discussions (Lee, 2004). These are most of the prominent systems that facilitate multimedia use today. Data flow between a client and server for Macromedia Breeze including with network firewall and database being studied in this research to avoid any interruption during the experiment (Figure 2).

Figure 1, Interface of macromedia breeze
The main independent variables used in this study are the communication channel and the task requirement for information visualization. A model that outlines the relationship between the input variables and the performance of group problem-solving is introduced in this study. A comprehensive classification system for group task types was introduced by McGrath (1984). The classification scheme for task types is known as the task Circumplex.

![Figure 2, Data flow between client and macromedia breeze server](image1)

Figure 2, Data flow between client and macromedia breeze server

The task Circumplex (Figure 3) classifies group tasks into four main categories (quadrants), those quadrants are: 1) Generating ideas, 2) Choosing the correct answer (intellective and decision-making tasks), 3) Negotiate (cognitive conflict and mixed-motive tasks), and 4) Execute (performance and competitive tasks). The classification of engineering and construction group tasks has implications for the group communication process. Two main tasks such as simple trusses and bridge design were applied using this task Circumplex.

![Figure 3, The task circumplex (McGrath, 1984)](image2)

Figure 3, The task circumplex (McGrath, 1984)
Performance of geographically separated groups using CMC technologies for problem solving during design process is one of the main areas of interest in this research. This goal has been achieved through comparing the performance of groups using traditional communication channels as FTF, and using emerging communication channels (Macromedia Breeze) such as CMC. In the computer-mediated channel, the text chat, audio and video feature allows the participants to exchange communication in real-time. The electronic white board enables all participants to simultaneously draw and view sketches on a shared space on their computer screens. The software application-sharing feature enables any participant to view and control a software file (e.g., SketchUp drawing) that exists on his/her partner's computer (Figure 4). The meeting room for the experiment at Figure 5 is a dedicated meeting area completed with computer, tablet and equipped with sound proof rooms to avoid any interference during the experiment.

Figure 4, Video frame showing project participants during observation

Figure 5, Layout of FTF and CMC meeting room
Referring to Figure 4, subjects were invited to participate in the experiments on a voluntary basis. All participants had undergraduate degree level engineering experience relating to the construction industry. The group from which recruiting subjects have been recruited is limited to the graduate students in the Civil Engineering Division at Cardiff University. A total of 18 subjects (3 females and 15 males) have so far participated in the experiments. The subjects were arranged into groups, each containing two-participants. As the primary research purpose was to explore the communication channel and group performance interaction in construction project context during design process, it was felt to be more appropriate to develop design tasks that are relevant to the construction project environment than to use standard tasks. Observations included video and audio recording for each groups FTF and CMC then to be analysed using TEAM-IA.

3 Data Analysis and Evaluation

Three data collection tools were utilized: 1) qualitative observation of the problem solving and the communication process, 2) experimental task duration as a measure of group productivity, and 3) post-task questionnaire to measure the perceived effectiveness. All analyses were conducted at the group level. Nine group tasks were investigated across two communication channels (FTF and CMC).

![Durations of Task 1](image1)

**Average Time**
- FTF: 06:05:10
- CMC: 00:03:50

![Durations of Task 2](image2)

**Average Time**
- FTF: 06:02:53
- CMC: 06:04:37

Figure 6, Durations of task using communication channels.

The process of problem solving and communication was observed. Both participants have to follow detailed guidelines for solving the problem during the experiment. From Figure 6 (Task 1 with FTF mode), on average, participants spent more time in communicating in order to review and understand the partner's results and to make a joint decision on the given problem. The increase in task duration was a result of longer communication time needed to review results, correct errors, and reach an agreement on how to solve the problem. In Task 2, CMC has taken a longer time due to more challenging problem that needs them to use more drawing tools to perform the results. From here we can see that, the task that involved with more activities using CMC, will take longer time compare to FTF.
Each TEAM perspective characterizes meeting interactions as activity focused on different goals: project-oriented goals (workflow), socio-emotional goals (dominance, control, positive), artefact-oriented (use), and information-oriented (establishing common ground and moving towards realization). In each perspective, various process measures were established and calculated for FTF and CMC observations. Figure 7 shows a radar chart relating key process measures from each perspective. This visual tool is one method of identifying relationships between process measures and across observations. The observation results show that the chart comparatively gives opposite graph shape for each channel.

Legend:  
1 - Team Workflow (interaction as activity and action)  
2 - Socio Emotional (emotion, control, dominance)  
3 - Artifact Usage (interaction with digital or paper)  
4 - Model Focus (model focus versus action)  

Figure 7: Comparison of process measures from each group of the TEAM interaction analyses

To solving the given tasks during FTF, shows that subjects take more time to interact with artefacts where they are more likely to be silent and just focus on the task paper containing the task. They are less likely to participate in other interactions such as discussion, control and action. This shows that, they are not actively participating in the process but rather they are passively interacting.
which can be equated with socio-emotional behaviours like shame or shyness towards each other. One would not expect this to be happening because all the subjects already know each other. For some other reason, subjects are less willing to share their knowledge on solving the tasks during face-to-face.

The results show that subjects using CMC tend to work more in a team with more interaction in activity and action. By using online communication the meeting process become more active during the design process. Besides that, it gives subjects more creativity to solve the task by using technology tools in Macromedia Breeze. As we can see, technology can give better solution behaviour even when subjects located in different geographically separated groups.

In addition, the role of the task in mediating the effect of channels on performance was revealed. As a result, the understanding may help construction organizations to achieve more effective use of the emerging technologies such as computer-mediated communication to improve project communications. The findings associated with this study expand the current knowledge regarding the impact of communication media on work groups in general and is considered the first within the construction project domain.

4 Conclusion

Both meetings demonstrate a highly efficient and potentially improved method of performing a meeting during the design process. The comparison of the all observations and analysis of those comparisons give way insights into co-production issues and meeting process. This result is an initial summary of those observations. The goal of this preliminary study is to provide some initial subjective and quantitative results of the design process meeting interactions and actions outcome. Based on the questionnaire findings, the meetings were efficient, action-based, and productive. The quantitative findings based on the satisfaction surveys show that participants were satisfied with the meeting process and outcome. The TEAM-IA has developed an efficient process to review, identify, and resolve issues with the available technologies and project structure.

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References


