VIRTUAL ENVIRONMENTS: LESSONS FROM INDUSTRY TRANSFERRED TO DISTANCE-LEARNING EDUCATION

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It is essential for construction professionals to be able to work in teams. Information and Communication Technology (ICT) has significantly influenced the ways in which team members interact. The School of Architecture and Built Environment at the University of Newcastle is currently investigating the extent to which the three domains of People, Processes and Technology contribute to the effectiveness of virtual teams as part of a CRC Construction Innovation project.

This project is in the process of identifying the attributes practised by construction professionals which contribute to the successful outcome of construction projects. These attributes, or skills and attitudes, fall outside the domain of ICT competencies normally associated with working in the virtual environment.

Teamwork is not confined to industry. Many professional degree programs seek to replicate industry practice in as realistic a manner as practicable. Third year Bachelor of Construction Management distance-learning students at the University of Newcastle work in virtual teams to prepare an estimate, tender, tender construction program and cashflow forecast for a high-rise structure. The problems they experience in working in teams electronically mirror many of those encountered by their real-life colleagues.

This paper explores the extent to which educational virtual teamwork can benefit from industry-based research.

Keywords: virtual teams, teamwork, education.

INTRODUCTION

The worlds of industry and education have traditionally existed in an environment where people interact “face-to-face” (F2F). In recent times this has changed as developments in Information and Communication Technology (ICT) have altered the expectations and boundaries of people’s interactions. Introducing ICT into industry and business has allowed activities to occur at a distance, and has provided opportunities for organisations to engage in activities across considerable geographic distances. ICT has played a significant part in globalisation and expansion across international boundaries.

In a similar vein the world of tertiary education has also adopted ICT to service and support distance as well as on-campus learning. However, ICTs have not affected

education in its role of developing relevant knowledge, skills and attitudes for the next generation of workers. These activities need to occur in environments in which its graduates will work, and progression into the virtual arena is timely.

The industry based research reported in this paper was funded by the Cooperative Research Centre for Construction Innovation (CRC CI) (at http://www.construction-innovation.info/). The CRC CI is a national research, development and implementation organisation developing key technologies, tools and management systems to improve the effectiveness of the construction industry. The overall aim of the research project reported in this paper is to investigate ways in which construction professionals interact electronically with each other during the design of buildings and structures. It is part of a larger CRC CI project which focuses on the technologies which facilitate virtual design (i.e. ICT enabled design) and deals with the early stages of a construction project in which communication and collaboration models are being developed and revised. The element of this project which is of relevance to this paper is that which deals with identifying the generic skills used by individuals and teams when engaging with high bandwidth information communication technology.

The education component of this paper draws on experiences at Newcastle University, and reports developments in the School of Architecture and Built Environment.

GENERIC SKILLS OF VIRTUAL TEAMS

Salas et al (2000) define generic skills as the knowledge, skills and attitudes that a team member possesses when completing a task or communicating with fellow members in any environment. Generic skills are also defined as those that influence both individuals and teams. They are skills which are '*…transportable and applicable across teams'*. Table 1 illustrates these skills that form the basis of an effective team.

TECHNOLOGICAL IMPLICATIONS FOR VIRTUAL TEAMS

With the rapid development of and changes in technology, virtual teams may soon exhibit the same generic attributes as co-located teams, such as non-verbal interaction. When looking at the skills involved with both co-located and virtual teams, it is easy to say that technology has all of the answers; that the same skills seen in a co-located team can be utilised with technology in a virtual team. However, there are other issues to consider, such as: whether team members are operating synchronously or asynchronously, time differences, or whether the technology is available to all team members. The technology that enables teams to have full visual and verbal contact is currently more common within industry than it is in the educational world, even though the demand in the tertiary sector is toward more on-line learning.

In F2F meetings all contextual cues can be used; these include body language, eye contact, and changes in speech. These give information about the person speaking, how the message is conveyed, and the success of the communication (Driskell et al., 2003). Virtual team members can have difficulty communicating these verbal and visual cues. As mediums such as e-mail do not incorporate non-verbal communication and voice intonation, there can be significant misunderstandings which may lead to inter group conflicts (Riedlinger et al., 2004). Jaafari and Tooher (2002) outlined a number of constraints of virtual teams including:

- the lack of personal contact minimising the ability to use social cues and body language

- a lack of leadership hierarchy within the remote groups
- the members are reliant on technology; any fault in the system may result in communication being severed.

Table 1: Generic teamwork skills, adapted from Cannon-Bowers et al 1995 (in Salas et al., 2000).

Core Generic Skills & Definition	**Sub skills**
Adaptability • The use of compensatory behaviour and reallocation of resources to adjust strategies based on feedback	• Flexibility • Compensatory behaviour • Dynamic reallocation of functions
Shared situational awareness • When team members have compatible mental models of the environment within and outside of the team.	• Orientation • Team awareness • System awareness
Performance monitoring and feedback • Ability of team members to give, seek, and receive task-clarifying feedback.	• Performance feedback • Acceptance • Mutual performance monitoring • Procedure maintenance
Leadership/team management • Ability to direct and co-ordinate the activities of other team members particularly pertaining to performance, tasks, motivation, and creation of a positive environment.	• Task structuring • Motivation of others • Goal setting • Goal orientation
Interpersonal relations • Ability to optimise the quality of team members' interactions.	• Conflict resolution • Assertiveness • Morale building
Co-ordination • Process, by which team resources, activities and responses are organized to ensure that tasks are integrated, synchronised and completed within established temporal constraints.	• Task organisation • Task interaction • Timing
Communication • Information exchange between members using the prescribed manner and terminology.	• Information exchange • Consulting with others
Decision making • Ability to gather and integrate information, use sound judgment, identify alternatives, select the best solution, and evaluate the consequences.	• Problem assessment • Problem solving • Planning • Implementation

Ensuring that all members of a team have an appropriate level of technical expertise with new ICTs is also a challenge that comes with moving from co-located to virtual teams (Lahti et al., 2004).

Organisations cannot use the management strategies in virtual teams that are already in place for F2F teams. A clear definition of roles, responsibilities and objectives is needed to allow for a more structured work environment. The virtual environment is not one that allows open discussion to resolve issues of procedure, and clear boundaries and procedures must therefore be created for all levels of membership of virtual teams.

The move towards a virtual world is becoming ever more relevant to industry and education as organisations outsource activities across national geographic boundaries. The extent to which a team becomes virtual can be affected by a number of variables including the distance between members, the number of organisations the members

represent, the length of time the team has functioned together (Ratcheva and Vyakaram, 2001), and the experience (i.e. technical skills) of the members (McMahan, 1998).

VIRTUAL TEAMS IN EDUCATION

Working in teams is not unique to the construction industry. Many professional degree programs seek to replicate industry practice in as realistic a manner as practicable, and teamwork frequently forms an element of students' experiences, especially where degree programs are offered in F2F mode. However, the challenges confronting distance-learning students are more complex and demanding for students and staff alike. The remainder of this paper describes the way in which third year Bachelor of Construction Management (Building) distance learning students at the University of Newcastle work in virtual teams to prepare a tender for a high-rise construction project.

The "Learning Challenge"

The preparation of an estimate, tender, tender construction program, and cashflow forecast is an involved and time-consuming activity. Excellent guidance is provided by the Chartered Institute of Building (CIOB, 1997), and students are encouraged to base their submissions on examples of best practice provided in this and other texts. In industry, estimating and tendering is usually completed by teams comprising estimators, planners, and buyers who are sometimes assisted by site managers, plant and equipment experts, legal advisors and so on. Given unlimited time and resources, students could engage in learning activities on each of these topics, but there are clear advantages to be gained by constructing learning experiences that simulate the industry practice of individuals working together. One of the authors of this paper has facilitated such activities with construction students in an on-campus environment for several years (Sher 1996) and has recently adapted them to distance learning. Such a transition has only recently become feasible with the widespread uptake of the Internet, and the implementation by the University of an Internet based learning management systems (BlackBoard at http://www.blackboard.com/). Features this system provides include:

- on-line access to learning materials
- links to relevant electronic sources (including websites, databases etc)
- dedicated discussion areas and email facilities
- many other applications geared for pedagogy, including tests, recording of marks, provision of feedback from tutors, timetables and so on.

The estimating and tendering course is based on a Learning Challenge which is taken from real life projects. In the current iteration of the course, students have taken on the role of specialist reinforced concrete frame sub-contractors tendering for a multi-storey building in the Newcastle central business district. Students work in teams of three, and compete with each other for the hypothetical award of the contract to construct the building.

Students are provided with the documentation they would receive if they were working in the field, including drawings, specifications, quantities and so on. These materials are provided as hardcopy and electronically.

The BlackBoard Internet based learning management system

BlackBoard, as used in the estimating and tendering course, serves several purposes, including:

as an on-line reservoir of electronic resources…

Drawings, bills of quantities, specifications, briefing and similar documents are made available to students via the system. This practice replicates the use construction professionals currently make of information management systems (such as Aconex [at www.aconex.com] and BIW Information Channel [at www.powyr.com]).

as the medium through which students communicate with the client's representative...

Students frequently ask for clarification and explanation, in much the same way that estimators and planners request information from architects, engineers, quantity surveyors and other design consultants. Blackboard allows queries to be posted on an electronic "discussion board", and records the answers of the client's representative (in this case, the lecturer). This has the advantage of publishing queries and responses to all tenderers (i.e. groups of students) and avoids lecturers having to answer similar queries from individual groups. In addition, this practice ensures that lecturers provide consistent advice to all students.

as a virtual teaming environment…

These facilities are closest in concept to those described in the CRC CI project described earlier in this paper. Here students are able to communicate with members of their group in a secure and private environment. The facilities offered by BlackBoard include:

- **Email**, where students can send emails and attachments to each other as well the outside world.
- **Discussion boards**, which allow members of a group communicate **a**synchronously by posting and responding to messages from other members of their group.
- **Collaboration tools**, which allow group members to communicate synchronously by posting and responding to messages from other members of their group.
- **File exchange facilities**, which allow students to make electronic documents available to other members of their group.
- **Electronic whiteboards**, which allow students to communicate synchronously using free-hand sketches and text.

Facilitating Virtual teamwork using BlackBoard

We argue that the skills students exercise in the estimating and tendering exercise relate closely to those identified in the CRC CI project described earlier in this paper. A concise description of the activities students engage in is provided below.

Team formation

Students taking the Bachelor of Construction Management (Building) program are located predominantly in Australia, with concentrations in the Sydney / Newcastle area as well as Tasmania. There is also an expanding student body in Singapore. Recognising the fact that few, if any, know each other, a team formation exercise forms an integral part of the start of the estimating and tendering course. Students provide details of their background, work experience, aspirations and areas of interest on a BlackBoard discussion board, and select team members based on the details they read about each other.

Managing team activities
Students need to devise a strategy for satisfying the Learning Challenge and allocate activities between themselves. The nature of the challenge is such that students cannot work in isolation, as the tasks involved in preparing an estimate and converting it into a tender are inter-related. Students need to review each other's work and build on the efforts of others. Furthermore, they need to "log" their activities in the form of minutes of meetings, and accumulate evidence of work "in-progress". The logs and related evidence contribute to the overall assessment of the course. Further details are provided by Williams et al (2004).

Managing unsatisfactory team performance
Should a team member not perform satisfactorily, students dissatisfied with a colleague's contributions need to initiate a disciplinary process that reflects industrial relations practice. This involves notifying the student concerned of the aspects of their performance that are deemed to be unsatisfactory, giving them an opportunity to respond, and so on. See Sher and Williams (2004) for further details.

Collating and submitting team member's deliverables
Students need to combine their individual contributions into a coherent document and submit it electronically through BlackBoard.

It is informative to map the virtual teamwork core skills summarised in Table 1 with the activities described above. Table 2 lists the estimating and tendering activities and highlights the core skills that students need to demonstrate in their attainment.

Table 2: Core virtual teamwork skills mapped against estimating and tendering activities

	Core Skills							
Estimating and tendering activities	**Adaptability**	**Shared situational awareness**	**Performance monitoring and feedback**	**Leadership/team management**	**Interpersonal relations**	**Co-ordination**	**Communication**	**Decision making**
• Team formation	**x**	**x**			**x**		**x**	
• Managing team activities			**x**	**x**	**x**	**x**	**x**	**x**
• Managing unsatisfactory team performance			**x**	**x**	**x**			
• Collating and submitting team member's deliverables	**x**	**x**				**x**		**x**

Assessing Virtual teamwork skills

Assessment is an integral element of any educational experience. In the estimating and tendering course, the level of attainment of the virtual team skills (set out in Table 1 and summarised in Table 2) is assessed as a reflective exercise modelled on the RAPID (at http://rapid.lboro.ac.uk) and NURAPID web-based skills development and recording portfolios. An example of the framework within which students reflect is provided in Figure 1.

Figure 1: An example of the "reflective" framework used to assess "core skills"

REFLECTING ON 'CORE SKILLS' DEVELOPMENT			
Taking part in discussions and meetings	A	I have not reached a satisfactory level and have performed below my own expectations	**Evidence**
	B	I can make a valid contribution[1] to a discussion/meeting within a small, familiar group on a straightforward[2] issue or subject.	
	C	I can make a valid and effective contribution[3] to a discussion/meeting within a familiar group, small or large, on a specific issue or subject.	
	D	I can make a valid and effective contribution to a discussion/meeting within a familiar or unfamiliar group setting on more difficult matters[4].	
	E	I can make a valid and effective contribution, as well as play a leading role in a discussion/meeting within a familiar or unfamiliar group setting on complex and difficult matters, which other participants recognise as constructive[5] and providing clarity[6].	

Terminology

1. valid contribution: contribution that is factually correct, supported by some evidence, and is relevant to the subject under discussion and includes listening and responding appropriately to the input of others.
2. straightforward: subjects that are not contentious or do not have many issues involved.
3. effective contribution: contribution that helps determine the course of action resulting from discussion, or help change perceptions and attitudes of others involved in discussion.
4. more difficult matters: subjects that are controversial and complex, involving a number of issues and a variety of opinions etc.
5. constructive: helpful in reaching a conclusion.
6. providing clarity: enabling others to see or appreciate something that was not previously obvious, simplifying a complex thought or idea to allow others to understand.

This reflective exercise requires students to select a statement (A to E) that matches their level of attainment. This self-assessment activity needs to be corroborated with evidence that supports the student's claim. A wide variety of evidence is accepted by staff, including reference of minutes of virtual team meetings, transcripts from BlackBoard Collaboration sessions, relevant sections from students' group submission and so on.

CONCLUSIONS

This paper has described progress to date on a CRC CI research project which investigates the generic skills used by individuals and teams engaging with high bandwidth information communication technology. We have identified a range of skills and attributes which contribute to team effectiveness and these have been integrated into the learning environment of students involved in the Construction Management Program at the University of Newcastle. Using a virtual team context as a learning environment provides students with opportunities to acquire some of the technical skills required for the professional workplace. The paper documents a clear

match between the virtual skills required in the workplace, and those developed and assessed as part of an academic course.

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