COMMUNICATION MODES AND PERFORMANCE OF VIRTUAL DESIGN TEAMS IN AN UNDERGRADUATE BUILDING PROJECT

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Effective communication between parties in distributed design teams is essential for successful construction projects. However, there is little consensus and understanding on the factors influencing the distanced communication between these multidisciplinary parties. Many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination. This paper reports an on-going research project that aims to investigate the factors influencing the communication effectiveness of virtual design teams in a case project undertaken by final-year undergraduate students in two institutions in Canada and the UK. The empirical work involved a questionnaire survey of 69 students, comprising 32 UK (civil/structural engineering) and 37 Canadian (architectural) students. The findings suggest that there is tendency for different communication modes used by the two professions, with architects preferring visual and kinesthetic modes, and civil/structural engineers preferring aural and read/write modes, although this was not statistically significant (p=0.286). Higher levels of trust could be sustained by providing evidence of consistent performance over the course of the project. The architectural students and female participants are more likely to exhibit higher levels of trust to their counterparts and higher levels of satisfaction with team working. The findings reveal the potential influence of disciplinary training on the preferred communication modes and the development of effective virtual collaboration. Additionally, the research provides material for further reflection and may serve as a useful consideration for future development of a guiding framework for effective training of built environment professionals.

Keywords: communication, design, education, virtual teams.

INTRODUCTION

Construction works, by their very nature, are multi-disciplinary activities to achieve a common project objective. Although the diverse disciplines are believed to bring

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innovative ideas in the products and processes (Horwitz and Horwitz 2007), the parties involved require effective information exchange protocol if the project is going to progress and achieve its intended objective. In reality this is difficult because these parties may have different interests on a project, as an outcome of interacting influences in their social, business, legal and educational environments. One of the notable influences is the educational background and training of individual parties in their earlier years of engagement with the built environment sectors.

It is recognised that many causes of poor performance in construction emanate from communication problems between parties during the course of a project (Dainty *et al.* 2006). Often the problems remain hidden until the construction plan and design are implemented on site. Communication between parties in the design process should not be overlooked as the process has significant impacts on the downstream activities, and on the creation of added value to the construction facilities. Advance developments in information and communication technologies (ICTs) have made possible real time, distanced communication between parties in different locations (Gaudes *et al.* 2007). However, the 'interface' problems which may have existed between these parties could be further exacerbated by the need to communicate over distance within a time constraint in an increasingly interconnected and globalised construction sector. Many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination.

Developing a better communication practice in the industry requires fundamental rethinking of the education content and process of the future built environment professionals. Multi-disciplinary working presents a significant conceptual challenge for the students as this requires a comprehensive understanding of the interests and orientation of the other subject disciplines, and fit them in the 'jigsaw' of knowledge to produce the constructed facility. This understanding may get better as individuals obtain more experience from their exposure in the workplace practice. Further, there are attitudinal requirements that will facilitate successful multi-disciplinary working, for example, a willingness to accept other ideas, level of trust, preference to working in teams, the ease to establish relationships with others in the team, which are very much related to the culture at functional, organisational and national levels. These all should be better acquired through experiential learning, rather than infused through the process of knowledge transmission during lecture session. This issue presents a complex and intricate problem for construction educators, whose main responsibility is to prepare the future professionals for the industry. A project, sponsored by Hewlett Packard (HP), has been initiated to address this challenge by creating an authentic, multi-disciplinary, distanced collaborative working environment, designed to mimic a real industry practice. A greater understanding of individual's preferred communication modes and significant factors influencing the performance of virtual teams will contribute to addressing this challenge. This paper reports the initial findings of the investigation of a simulated virtual team project of final year undergraduate built environment students in two institutions in Canada and the UK. A questionnaire survey of 69 students comprising of 32 UK (civil/structural engineering) and 37 Canadian (architectural) students was undertaken. The data were analysed using descriptive statistics and chi-square tests. The following sections describe the definition of virtual teams and factors influencing effective virtual teams focusing on the development of trust and team diversity, a method to identify individual preferred communication modes, group work process/ research design and methods, before the presentation and discussion of the findings. Conclusions are drawn to illustrate what

the findings may mean for the construction education and industry professional practices, and to describe future research.

TRUST AND PERFORMANCE IN VIRTUAL TEAMWORK

In this research, virtual teams comprise geographically distributed members who may have diverse expertise and responsibilities, but have to work together as a team to achieve a common project objective. Geographical separation of team members prevents frequent face-to-face communication and physical interactions for decision making, which has brought challenges to managing virtual teamwork. That is, it would be inappropriate to assume that factors influencing collocated teams effectiveness are valid for virtual teams (Potter and Balthazard 2002 c.f. Kirkman *et al.* 2004). Extensive research has been conducted to understand how and why teams achieve desired outcomes, however relatively little is known about the elements that determine and influence virtual team performance (Lee-Kelley and Sankey 2008, Algesheimer *et al.* 2011). Gaudes *et al.* (2007) compiled a comprehensive list of factors that contribute towards the effectiveness of virtual teams, but there is no pointer of which factors are the most appropriate for a certain context, and the same list could also be applicable for traditional collocated teams. Given the limitation of resources, it would be impractical to consider all factors, but the research identified trust-related factors inherent within individual members, that may influence the effectiveness of a virtual team.

Team development describes a progression of a team from merely a collective group to a performing team that capitalises the effort of each member into synchronised actions for a common objective. A team is built on trust. Traditionally, trust is nurtured through personal interactions between members over time. Teams develop higher levels of trust when they involved on more social interaction (Jarvenpaa and Leidner 1999 c.f. Gaudes *et al.* 2007). When team members are separated, they are less likely to establish one-to-one relationships (Chinowsky and Rojas 2003). Shortage of time due to commercial pressure further prevents the development of trust in teams. Several other factors that may contribute to the lack of (the development of) trust in this project are different disciplines involved, different working practices (i.e. building standards, regulations, legal framework), and different culture at functional, institutional and national levels (Zolin *et al.* 2004). In addition to project-based nature of construction, working in a virtual team does not enable the anticipation of future association which promotes trust and cooperation. Collocation allows teams to foster shared values, expectation, cohesion and increase commitment to objective (Daim *et al.* 2012). The absence of frequent face-to-face interaction, aligned expectation and team cohesion may increase the propensity of conflicts between team members (Kankanhalli et at. 2007).

In virtual collaboration, the word 'trust' is interpreted as perceptions of trustworthiness (Hardin 2000; c.f. Zolin ibid.). Mayer *et al.* (1995) and Zolin (ibid.) recommended three dimensions underlying perceived trustworthiness: benevolence, ability, and integrity. As defined in Zolin (ibid.), benevolence is the positive perception of the trustee towards the trustor (Mayer ibid.). Benevolence can be the outcome of parties having successfully aligned interests and goals in the project (Hardin 2000, Das and Teng 1998). Ability is the perception that the trustee has the skills and resources needed to perform the task for the project. Zolin (ibid.) distinguished between the skills and effort in that high level of effort (i.e. diligence) does not guarantee success if the party does not have the required skills to undertake

the task. In this case, levels of trust may suffer. Integrity refers to the trustee's honesty and moral character as perceived by the trustor. Trustee having integrity is seen to be more likely to behave in honourable ways and not deceive their co-workers about their intention to meet commitments and expectations (Zolin ibid.).

DIVERSITY IN VIRTUAL TEAMS

Past research on the relationships between team diversity/ composition and team performance has been inconclusive (Kankanhalli et at. 2007). Some scholars argue that diverse members will bring benefits to the team in terms of new perspectives to problem solving and innovative ideas (Staples *et al.* 2005 c.f. Gaudes *et al.* 2007), others found heterogeneous teams can experience significant difficulties resulting from tension and conflict (Horwitz and Horwitz 2007, Kankanhalli et at. 2007). In an evaluation of virtual team performance, Lee-Kelley and Sankey (2008) found that time zone and cultural differences affected communication and relations more than collocated team. In this research, team diversity has been manifested in bio-demographic/social and functional diversity (Kankanhalli et at. 2007). Bio-demographic/social diversity includes individual characteristics such as age, gender, race/ethniticy (Horwitz and Horwitz 2007). For the purposes of this research, only 'gender' was included. 'Age' is fairly uniform due to the students being in the same year. Many of the participating students are from overseas, and one would expect diversity of race and ethnicity in the groups. However, for ethical reasons, 'race/ethnicity' was not included in the research. Functional diversity arises from differences in educational background, working experience, and functional expertise among team members (Kankanhalli et at. 2007). The variables included in this research were working experience in the industry, experience in distanced collaboration, and educational background (civil/structural engineering and architecture).

IDENTIFYING PREFERRED COMMUNICATION MODES

Individuals have preferences on the way they work. Due to external factors such as economic pressure, organisational procedures, (domineering) colleagues, the preferences may not align well with the work they actually do. The mismatches can act as an indicator of possible role stress (Lee-Kelley 2006). In the context of the project, work type preference or skills or psychological mismatches in any areas of schedules, priorities, manpower sourcing, technology, administrative procedures, personality and cost, can cause a project to disintegrate (Thamhain and Wilemon 1975). The same information can be presented in different ways; the choice is made by individuals based on their cognitive process of sense making. The mismatches between preferred and actual communication modes may lead to less effective exchanges of information, misunderstanding, disputes and stresses. In educational context, the VARK (Visual, Aural, Read/write, Kinesthetic) questionnaire was developed by Neil D. Fleming in 1987 as a means to identify an individual's preferred communication modes (Marcy 2001). Fleming and Mills (1992) found that many students attributed their learning difficulties to the form in which course material was presented. That is, some students found they had difficulties learning in situations where the course material was only presented orally, while others reported similar difficulties when the material was primarily in written form. In comparison to other learning style questionnaires (e.g. Kolb's experiential learning style), VARK has a particular focus on identifying the preference of individuals to take-into and give-out information from their mind. The VARK questionnaire helps users to understand their

preferred communication modes, and allows them to reflect, and then facilitate their subsequent learning. Since it was created, VARK questionnaires have been widely adopted not only in education context, but also in businesses. Through online surveys since 2001, a large database has been collected (with around 2 million responses in 2011 alone) and analysed according to demographic and occupational backgrounds of the respondents. Self-evaluation of the results of the questionnaire produced a reasonable degree of accuracy, as was explained in Fleming (2012).

GROUP WORK PROCESS

During the course of the project, students worked in groups based on a project brief. A project scenario was developed based on a real academic building, which would be built in the future to replace the existing building. The comprehensive project brief included (i) description of purposes of building, requirements of facilities (e.g. rooms, area, environmental aspects), site location and constraints (relationships with the existing building and facilities in the surrounding area), requirements on group formation and work process (meetings, roles of individual student), assessment of tasks with detailed requirements for each project phases, and peer assessment using Web-PA system (see Wilkinson and Lamb 2010 for description of Web-PA). In addition to these, design guidance of building standards, structural design codes, poster and presentations were also provided.

Local groups of four students were formed in the participating universities. The UK students studied civil/structural engineering, whereas the Canadian students studied architecture. Each group was asked to produce one A2-sized poster which advertised the skills in the team. The teams reviewed the different team posters with a view to negotiating and agreeing with a counterpart team for the formation of a company. The teams conducted weekly meetings, and appointed a company leader and secretary that were rotated every four or five weeks, thus enabling each member of the team to carry out each role. The company leaders chaired the weekly project meeting, monitored and co-ordinated the work of the group, ensured that submission dates were met and generally oversaw the day-to-day running of the project team. The company secretary took the meeting minutes, noting any important points discussed, and deputised for the group leader in the event of their absence. The marking scheme combined individual and group marks for each task. The individual marks were derived from the assessment of the task that the individual was responsible for. The group mark was peer-assessed using Web-PA system. The system provides a control mechanism to discourage students being 'passengers' in the team. Further pedagogical benefits from peer assessment to the skills formation in a group work is explained in Wilkinson and Lamb (2010).

RESEARCH METHODS

A programme of data collection was developed to capture and monitor a number of important aspects of team collaboration (e.g. conflicts, trust, performance) throughout the project duration (one academic year). This included a series of interviews, questionnaire surveys, personal reflections, grades and tutor assessment feedback at different points with both students participating in the team activity and students on the same module who had opted to work collocated with students from the same institution ('non-participating' students). The questionnaire survey, reported in this paper, sought (i) background information (including course, gender, working experience, experience of distance collaboration), (ii) aspects of distance collaboration/team working (such as trust, quality of work, risk, perception on other

team members, communication, face-to-face meeting, satisfaction), (iii) VARK questionnaire, which comprises 16 questions (explaining 16 different situations), each with four different answers, that reflect different ways of taking and giving information for the same situation. For questions related to distance collaboration, the respondents were asked to express their level of agreement against a four-point scale from 1 to 4 where 1 indicates 'strongly disagree'; 2 'disagree'; 3 'agree'; and 4 'strongly agree'. Neutral middle point ('neither agree nor disagree') was not included to make respondents more discriminating in their responses, and this makes respondents more thoughtful and leads to more precise responses (Busch 1993, Garland 1991, Reid 1990). Therefore, the engagement with and accuracy of the scale used by the research may be improved through the use of a four-point scale. The responses to the VARK questionnaire were coded according to corresponding preferred modes (V, A, R or K). The respondents were allowed to choose multiple answers to each question. The responses corresponding to V, A, R, and K were then summarised. The highest score indicates the preferred mode. If there is a tie between two or more modal preferences, the result is considered a double or triple tied preference (Fleming 2012).

The questionnaires were distributed to all participating students before the project commenced. They were given around 15 minutes to complete this short questionnaire (three pages in total), and their responses were collected by the tutors during the session. This process yielded 69 responses, including 32 UK (civil/structural engineering) and 37 Canadian (architectural). Only very few did not hand-in their responses (2 students). The responses were analysed using descriptive statistics and chi-square tests obtained from SPSS software. Using students as the participants brought several advantages, notably higher response rate to the data collection exercises and importantly, higher degree of control over the tasks required in this 'experiment' (in terms of e.g. comparability across the groups). Although the use of students as respondents aligns well with the research focus on early education of built environment professionals, generalisation to the industry professionals should be drawn with caution, as they would have acquired more experience and other influences in the workplace. The results are presented in the following section.

RESULTS AND DISCUSSIONS

From a total of 69 responses, male students represent 66% and female 34%. Two-thirds (66%) had no work experience in the construction industry. Very few (2 students) had experience in distance collaborative before this project. Apart from experience in distance collaboration categories, the relatively even distribution of responses allow comparison between categories (e.g. comparison of responses between UK and Canada, male and female) to explore the relationship between categories and the other variables.

The analysis of 11 factors influencing distance collaboration revealed that the need to check progress and quality of other team members scored the two highest, honesty of other members was the third highest score. This confirms the need for conformance with individual expectations, and that trust will need to be confirmed by evidence of performance. Table 1 presents significant relationships between (institution and gender) categories and other variables in the questionnaire. The analysis revealed some evidence of a relationship between institutions and three perceptions of distance collaboration, namely (i) checking progress and (ii) quality of work, and (iii) honesty of other members. However, the relationships would not appear too strong (p-value of

0.094, 0.098 and 0.058, respectively). This indicates that higher levels of trust (in terms of 'integrity') could be sustained by providing evidence of consistent performance over the course of the project. An observation of data suggests that a higher degree of trust between team members is more likely to be found between students at the Canadian university (i.e. more students chose 'strongly agree', p=0.058). An explanation for this may be found in the fact that architecture students are required to spend more of their time working with their colleagues in the studio, which allows higher level of face-to-face interactions, which in turn, facilitates the development of trust. This is further supported by the significant relationship between gender and four perceptions of distance collaboration: (i) competence of team members (p=0.020), (ii) honesty of other members (p=0.027), (iii) other member completing work commitment on time (p=0.069), and (iv) individual satisfaction with working in a team (p=0.034). This confirms that higher degree of trust (in terms of 'integrity') between team members is more likely to be found between female students, who were mostly from the Canadian university. They are also more likely to derive higher levels of satisfaction from working in teams.

The results of the VARK questionnaire in relation to institution categories (i.e. UK and Canadian institutions) are presented in a histogram in Figure 1. It can be seen that UK students tend to prefer aural and read/write modes, whereas Canadian students tend to prefer visual and kinesthetic modes. The same tendency was also found in the gender categories. However, the relationships were not significant (with p-value of 0.286 and 0.294 respectively). The VARK website, which has been online since 2001, can provide a comparison of this finding with the general student population. Based on online responses from around 80,000 students from different levels (including universities, colleges and high schools), Fleming (2012) found significant differences (based on chi-square analysis) between males and females in their preferred communication modes with men have more kinesthetic responses and women more read/write responses. If the responses in this research should demonstrate the same tendency, the finding of our research suggests that training in the subject disciplines can influence the preferred communication mode of the students. In this case, there is tendency for different communication modes by the two professions, with architects preferring visual and kinesthetic modes, and civil/structural engineers preferring aural and read/write modes. There is no relationship between industry experience and VARK categories (p=0.603). However, there is a tendency for those who have had industry experience to prefer a kinesthetic mode of communication.

Table 1: Significant relationships between categories and other variables

Category versus Variable	Probability value
Institution vs. the need to check progress	0.094
Institution vs. the need to check quality	0.098
Institution vs. honesty of other members	0.058
Gender vs. team member competence	0.020
Gender vs. team member honesty	0.027
Gender vs. complete work commitment on time	0.069
Gender vs. satisfaction with teamworking	0.034
Institution vs. VARK	0.286
Gender vs. VARK	0.294

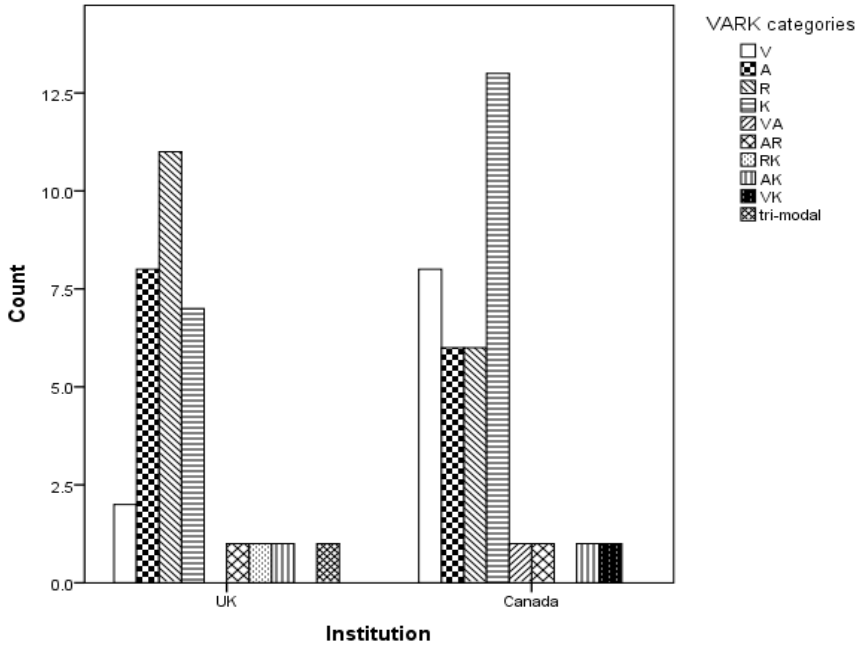

Figure 1: VARK profile for institution categories

CONCLUSIONS

Advances in ICT and changes of social, economic and legal requirements of the modern globalised world have redefined the way the parties in construction work together and communicate. Distributed team work across geographical boundaries has become more common and naturally unavoidable in modern construction. This represents a significant challenge to the industry as many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination. This research has considered factors that may influence the effectiveness of virtual team working through an investigation of authentic simulated learning environment where students work on a case study project. The investigation examines the factors during the training of the built environment students, who will

bring the skills and knowledge to their workplace after the completion of the study. One can expect that understanding of the factors during this training would allow appropriate adaptations to be made in the programme (i.e. curricula) so that the students would be better prepared to meet the requirements of virtual collaborative practice.

The findings suggest that different disciplines in this project tend to prefer different communication modes with UK students (civil/structural engineers, male majority) preferring aural and read/write modes, whereas Canadian students (architects, female majority) preferring visual and kinesthetic modes. A comparison of this finding with the general student population, as demonstrated by Fleming (2012), reveals the potential impact of disciplinary training to the students' preferred communication modes. Further evidence indicates that higher levels of 'integrity' trust could be sustained by providing evidence of consistent performance over the course of the project, and higher degrees of 'integrity' trust between team members is more likely to be found between female students, who were mostly from the Canadian university (architects). They are also more likely to derive higher levels of satisfaction from working in teams. If the 'integrity' trust is regarded as an essential foundation for an effective teamwork, the disciplinary training may have an influence on the development of effective virtual collaboration. It could be argued that architectural students are required to spend more of their time working with their colleagues in a studio, which allows higher levels of face-to-face interactions. This 'collegiate' training may facilitate the development of 'integrity' trust. However, in a virtual collaborative environment, this 'integrity' trust would need to be nurtured by consistent demonstrated performance (e.g. meeting deadlines and expectations of other members). This reciprocal relationship is further emphasised by individual satisfaction (as one measure of performance of teamwork) which was found to be derived from the performance of the other members.

The findings have implications on education and industry practices that can cut across national boundaries. The findings can be considered as a pointer to the possibility that construction educators may have not sufficiently addressed the grand idea of 'integration' between the disciplines/professions in the built environment, despite all the rhetoric and efforts that have been expended. Radical changes would not happen overnight, but multi-disciplinary collaborative working over distance should be made a fundamental element of the curricula. Currently, this skill is still considered high added value for employability, however in the future, this will be an essential part of built environment education. The research presented here has several limitations. Firstly, a small data set would have denied stronger results of the statistical tests. Secondly, other performance measures (such as assessments from tutors and industry practitioners, team cohesion) would need to be examined and incorporated in the research to investigate their relationships with the factors. Thirdly, generalisation to the general (practitioners) population should be drawn with caution, as practitioners would have acquired more experience and other influences in the workplace. These limitations suggest future research areas.

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