Key Success Factors and Guidance for International Collaborative Design Projects

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KEY SUCCESS FACTORS AND GUIDANCE FOR INTERNATIONAL COLLABORATIVE DESIGN PROJECTS

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Abstract

In the built environment (BE) sector, the co-creation process of design demands understanding of requirements (as viewed by parties involved), mobilisation of tacit knowledge, negotiation, and complex exchange of information. The need to collaborate over distance has further exacerbated the complexity of the process, and, in itself, represents a significant challenge for BE professionals who are increasingly expected to undertake this process within globally distributed virtual teams. The research aims to identify key success factors and develop guidance for international collaborative design projects, via the implementation of collaborative design courses in UK and Canadian universities over three academic years. Questionnaire surveys, focus groups, observation of online meetings, personal reflections provided data for the analysis. The findings reveal the significance of the perceived risk of collaboration and a difference in preferred communication mode between architects and civil/structural engineers. These findings suggest the impact of training in the subject discipline, and that the opportunity for co-located working has helped the development of trust. The guidance is aimed at BE educators who wish to implement this activity in their courses.

Keywords: *collaborative design, communication mode, virtual team*

INTRODUCTION

In the early design process of built facilities, communication between parties from different disciplines has potentially significant impacts on downstream activities, and on the creation of added value. At this early stage, design problems are by nature often not clearly defined and can be characterised by vague initial requirements, partially specified goals and indefinite possible solutions (Tezel & Casakin 2010). To produce a satisfying solution requires an iterative and creative collaboration between parties. This co-creation process of design involves mobilisation of knowledge which is often tacit and embedded within individual disciplines. The collaboration process has been the subject of research in the last two decades, which have produced process models and IT tools (e.g. Kagioglou *et al*., 1998; Austin *et al*., 2000; Bouchlaghem *et al*., 2005), and suggested behavioural change and innovative procurement arrangements to enable better collaboration (e.g. Akintoye & Main, 2007). Despite some improvements, poor communication remains one of the root causes of mediocre performance in design and construction (Dainty *et al*., 2006).

Advance developments in information and communication technologies (ICTs) have made possible real time, distanced communication between parties in different locations. Increasing international collaboration in the building industry means that more professionals will be required

to work in virtual teams within an online platform. To ensure effective performance, these parties have to manage content space (i.e. activities to be undertaken, problems to be resolved) and relational space (i.e. social interaction with possible conflicts and opportunities). Importantly, the team needs to achieve a high level of collaboration awareness (Leinonen *et al*., 2005). This online mode of working is particularly challenging given the complex design process, requiring rapid exchange of information, in addition to strongly ingrained disciplinary divisions between parties. This is inherent within the modus operandi of the industry, and has created structural and cultural barriers which inhibit integration, resulting in inefficient processes and sub-optimal solutions to the client's problems. Arguably, it is also reflected in the current education system of the built environment (BE) subjects, reinforcing the culturally-ingrained 'disciplinary silo' in the construction industry (Banwell 1964, Latham 1994, BAF 2015).

Multi-disciplinary working presents a significant cognitive challenge for students as this requires a comprehensive understanding of the interests and orientation of the other subject disciplines, and the need to fit these in a 'jigsaw' of knowledge to produce the constructed facility. This understanding may improve as individuals obtain more experience from their exposure to workplace practice. Further, there are attitudinal requirements that will facilitate successful multi-disciplinary working, for example, a willingness to consider and accept the ideas of others, level of trust, preference for working in teams, the ease of establishing relationships with others in the team, which are very much related to culture at functional, organisational and national levels. These can all be better acquired through experiential learning, rather than infused through the process of knowledge transmission during a lecture session. Another important challenge is the potential mismatch of preferred communication modes between parties from different disciplines. Due to inherent cognitive processing, individuals may have preferences for the way they wish to receive and give information. The same information can be represented 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. Knowledge of learning styles would permit individual learners to adopt appropriate strategies (i.e. use of representations) which can facilitate better understanding and communication. On the other hand, tutors would also be able to adopt the most effective teaching methods for the learners. Learning styles would also allow an evaluation of the impact of training in the BE disciplines; whether students in different disciplines may exhibit different learning styles, and whether they prefer certain representations of information. Currently, there is little knowledge on the relationship between BE subject disciplines and preferred communication mode.

The recently published report by BIM2050 group (2014), commissioned by the UK Construction Industry Council, illustrates the future of working in the BE sector, and identifies the education and skills requirements to meet future challenges to the year 2050, in the context of global competition and uncertainty, increasing complexity of built facilities, depleting resources and emerging technologies. The report highlights the ever-important integration in the design and construction process, suggesting that a future mode of working requires graduates who can work across disciplinary and geographical boundaries. In Canada, a survey by Digicon and IBC (2013) suggests that industry growth in the use of Building Information Modelling (BIM) technology relies on the education of BE professionals. This projection of skills requirements for the 21st century could have profound implications for the provision of BE education. Therefore, there is a need to rethink BE education systems to prepare graduates to harness the opportunity given by emerging technologies to work in a globalised industry. Importantly, BE educators should introduce curricula which can provide BE students with essential experience and skills required to work and collaborate across disciplines, cultural and geographical boundaries. This presents a complex and intricate problem for BE educators, whose main responsibility is to prepare the future

professionals for the industry. Despite its significance for industry progress, little is known on how BE educators can implement these curricula more effectively.
Given the above challenges, the key research questions which this paper seeks to address are:

1. What are the factors influencing the performance of collaboration in virtual teams?
2. Is there any difference in preferred communication mode between parties from different disciplines in the building design process?
3. What strategies should be deployed to achieve effective online collaboration? How can these be used by BE educators to incorporate collaborative design projects within the curricula?

To address these questions, research was initiated by implementing an authentic, multi-disciplinary, distanced collaborative design project which mimics industry practice. This paper reports the findings of the investigation of virtual teamwork of final year undergraduate BE students in two institutions in the UK and Canada. They were required to design a building project and collaborate over the internet using various modes of communication including Skype, email, Dropbox and GoToMeeting. They undertook a process of co-creation of a building design over a geographical distance. This design project was repeated in three consecutive academic years. To address the first two research questions, each year, a questionnaire was distributed in two phases at the beginning of the first semester and at the end of the second semester. In the third academic year, the project involved the use of GoToMeeting desktop sharing which permits real time interaction and discussion of building design objects, such as plans, drawings and 3D models. A greater understanding of significant factors influencing collaboration in the virtual teams and preferred communication modes of individuals from different disciplines will help BE educators to develop appropriate strategies to facilitate collaboration and enhance the skills of students. Through observation of meetings, focus group interviews and analysis of individual personal reflections, guidance for effective practice in collaborative building design project was developed. The following sections present a review of relevant literature which provides the underpinning knowledge for the development of the research. A method to identify individual preferred communication modes, collaborative design process, research methodology and methods are described, before the presentation and discussion of findings and the guidance for effective practice in collaborative design projects. Conclusions are drawn to illustrate what the findings may mean for construction education and industry professional practices, and the limitations are described with further research.

COLLABORATIVE DESIGN PROJECT

The collaborative design project is considered part of the problem-based learning which is often equated to inquiry-based learning, project-based project-, product-, process-, people-based learning (Fruchter, 1999). Although these have slightly different meanings, such terms rest on common philosophical ground in that the learning centres around student activities; the students learn more effectively from the activities they undertake and experience first-hand, rather than from listening to traditional lectures. Here, ‘problem’ could be a (hypothetical or real) project, scenario, case-study, research question or similar in a classroom, work-based, laboratory-based or other appropriate setting and for which a range of solutions or responses are appropriate (Wilson-Medhurst, 2008). Collaborative activities enrich the learning process, allowing the learners to share and enhance knowledge in a group work setting, and represent the practice of multi-disciplinary design in the industry. However, the idea of a collaborative design project is not new, and is a feature of BE courses around the world. For example, Barry *et al*. (2012) describe the development of the capstone design course in Purdue University, which has been team-taught since the early 1960s. Some recent examples, such as Bhandari *et al*. (2011), Peterson *et al*. (2011), Soibelman *et al*. (2011), Wolcott *et al*. (2011), Korkmaz (2012), Stanford *et al*. (2013), Solnosky *et al*. (2014), are varied in their focus with different objects of design, supporting

technologies, disciplinary composition and locations of team members, previous training and education levels (Soetanto *et al*., 2014). Most were implemented within one institution which makes possible regular offline (face-to-face) communication between students (e.g. Tucker & Rollo, 2006; Barry *et al*., 2012; Solnosky *et al*., 2014), but fewer include collaboration between students from two or more institutions from different geographical locations (such as Fruchter, 1999; Hussein & Peña-Mora, 1999; O'Brien *et al*., 2003 and Becerik-Gerber *et al*., 2012; Soetanto *et al*., 2014). Previous research studies have considered the effectiveness of distributed project teams (Gaudes *et al*., 2007; Kankanhalli *et al*., 2007) and the impacts of distance collaboration on the outcome of a design process (Dossick *et al*., 2015).

The challenges of communication in a distributed team

Geographical separation of the team members prevents face-to-face communication and interaction which is often a necessary condition in the problem solving sessions to achieve an optimum design outcome. Despite extensive research conducted to understand how and why teams achieve desired outcomes, relatively little is known about the elements that determine and influence virtual team performance (Lee-Kelley & Sankey, 2008; Algesheimer *et al*., 2011). Gaudes *et al*. (2007) compiled a comprehensive list of factors that contribute towards the effectiveness of virtual teams, and grouped them against an inputs-processes-outputs model and facets of individual, team, leader, organisation, project, and technology. However, there is no pointer to which factors are the most appropriate for a certain context, and arguably the same list could also be applicable for traditional co-located teams. Further, they highlighted the need to consider the context and systemic association between micro (i.e. individual, team) and macro (i.e. organisation, company in the supply chain) levels when considering factors influencing the effectiveness of a virtual team.

The literature on virtual teamwork shows consensus that trust is the critical factor for maintaining team effectiveness. In virtual collaboration, the word 'trust' is interpreted as perceptions of trustworthiness (Hardin, 2000 c.f. Zolin *et al*., 2004). 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). Ability is the perception that the trustee has the skills and resources needed to perform the task for the project. A 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, the level of trust may suffer. Trust also depends on the individual perceptions of those in the collaboration. A person having integrity is seen to be more likely to behave in honorable ways and not deceive their co-workers about their intention to meet commitments and expectations (Zolin *ibid*.). Mayer (*ibid*.) and Zolin (*ibid*.) argue that the perception of risk also influences perceived trustworthiness and trust. Thus, when the perceived risk is high, higher perceived trustworthiness may be required to trust the other. Collaborating in a geographically-distributed, multidisciplinary team may impose a higher risk (as perceived by individual members) due to dependence on one another's skills to complete the work, difficulty to know one anothers' work progress, and difficulty in reaching a shared understanding (Zolin *ibid*.; Leinonen *et al*., 2005).

The absence of social interaction in virtual teams is likely to limit the development of high levels of trust, although higher trust and cohesion could be achieved when team members are involved in social interaction earlier in the project (Chidambaram, 1996; Jarvenpaa & Leidner, 1999 c.f. Gaudes *et al*., 2007). In co-located teams, trust is nurtured through personal interactions between members over time, as time would also permit feedback, sharing and support between members, which facilitate team cohesion and develop team identity (Hertel *et al*., 2005 c.f. Gaudes *et al*., 2007). When team members are separated, they are less likely to establish one-to-

one relationships (Chinowsky & Rojas, 2003). As trust is developed over time, reduced time for interaction due to financial pressure can thus serve to prevent the development of trust in teams. Several other factors that may contribute to the lack of (the development of) trust are: the different disciplines involved, different working practices (i.e. building standards, regulations, legal framework), and different cultures at functional, institutional and national levels (Zolin *ibid*.). In addition to the transient project-based nature of construction, working in a virtual team does not enable the anticipation of future association which promotes trust and cooperation. Co-location allows teams to foster shared values, expectation, cohesion and increase commitment to an objective (Daim *et al*., 2012). The absence of frequent in-person interaction, aligned expectations and team cohesion may increase the propensity for conflicts between team members (Kankanhalli *et al*., 2007). These conflicts can be further exacerbated by the mismatch of preferred communication modes between individuals from different disciplinary backgrounds, as explained in the following section.

Preferred communication modes

In the building design process, a mismatch in preferred communication mode can hamper the creative process of co-creation of building design, whereby interacting individuals are expected to understand one another's mental schema and maintain a high level of collaboration awareness. Given that the creative design process involves information exchange and learning activities, an individual's learning style would have a strong association with their preference to receive and give information. For example, Demirbas & Demirkan (2003) found the effect of learning styles and the type of representation used to solve design problem on the outcome. Yazici (2005 cited various authors) indicated that individual characteristics such as psychological profile and learning preferences were likely to influence performance. Here, there is a need to define an appropriate learning style inventory to investigate the preferred communication modes of members of multidisciplinary team.

Despite long-term use and popularity of the term 'learning style', there is still disagreement about its definition and relationships with cognitive styles and learning ability, as well as a lack of consensus on what a learning style inventory should include (Leite *et al*., 2010). Kolb's (1984) experiential learning style focuses on the cognitive process of learning style (i.e. how individuals process information in the brain). 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). In comparison to Kolb's (1984) experiential learning style, VARK focuses particular on identifying the preference of individuals to take in information coming to them and the ways by which they like to convey their information (Fleming, 2015). Fleming & 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. The VARK questionnaire helps users to understand their preferred communication modes, and allows them to reflect, and then develop appropriate strategies to facilitate their own learning. Since it was created, VARK questionnaires have been widely adopted not only in an education context, but also in businesses. Through online surveys since 2001, a large database has been collected and analysed according to the demographic and occupational backgrounds of the respondents. The VARK questionnaire was employed in this case to identify the preferred communication mode and the differences between members of each building design team.

The need for research

Despite its potential benefits, working in geographically-distributed, multidisciplinary teams represents a significant challenge for their members. Previous research studies tend to focus on

how their performance differs to that of traditional (i.e. co-located) teams, and attempt to understand the factors influencing the performance of a virtual team. However, given the dynamic of a virtual team, variability of implementation context and approaches adopted (Solnosky *et al*., 2014), the performance of the team over a longer time, its influencing factors and impact are difficult to assess objectively (Becerik-Gerber *et al*., 2012; Soetanto *et al*., 2014). O'Brien *et al*. (2003) and Becerik-Gerber *et al*. (2012) found that remote collaboration is not always successful and often less effective than face-to-face offline meetings. Communication technologies are often blamed for the poor performance of virtual teams, but they are not the root cause of problems; although they could amplify the discrepancy and other barriers which already exist, such as the professional ethos of virtual team members (Soetanto *et al*., 2014). Such issues are further exacerbated by the lack of guidance on how to implement a successful collaborative design project. The inconsistency of the outcomes and lack of implementation guidance do not provide sufficient confidence for individuals to work in virtual teams. Ultimately, this could prevent individuals from adopting virtual teamwork, which has the potential to be an effective cost-saving strategy.

The main contribution of this paper is to identify the key success factors influencing multi-disciplinary, distributed team interaction and collaboration, and to present a guidance regarding an international collaborative design project. Specifically, the research aims to understand how the perceptions of collaboration and preferred communication mode differ between members of a multidisciplinary virtual team. A greater understanding of these differences will allow the identification of conflicts, the evaluation of the impact of disciplinary training, and the development of appropriate strategies to enhance performance. In the long-term, this knowledge will allow more consistent outcomes to be obtained. Simultaneously, the guidance will not only facilitate this goal, but also help BE educators to implement effective online collaborative design projects in their curricula. A description of the collaborative design process adopted in the research is explained in the following section.

COLLABORATIVE DESIGN PROCESS

International teams were formed from local groups of four students in each participating universities. These groups then worked on a project brief, which was developed collaboratively by tutors, based on a hypothetical project scenario. The project brief included (i) description of intended purposes of the building, requirements of facilities (e.g. rooms, area, environmental aspects), site location, investigation and constraints (relationships with the existing building and facilities in the surrounding area), operational requirements of group work (i.e. guidance of meetings, roles of individual student), assessment of tasks with detailed requirements for each project phases, and peer assessment using the Web-PA system (see Wilkinson & Lamb, 2010 for description of Web-PA). In addition to these, design guidance regarding building standards, structural design codes, posters and presentations were also provided. Throughout the academic year, the tutors were present, not only as the client, but also to support the collaboration on a consultancy basis and, sometimes, to act as a mediator should relationship issues in the teams arise. The mediator has an important role in the process of virtual collaborative learning (Soetanto *et al*., 2014).

The teams conducted weekly meetings, and appointed a team leader and secretary that were rotated every four or five weeks, thus enabling each member of the team to carry out each role. The team leaders chaired the weekly project meeting, monitored and coordinated the work of the team, ensured that submission dates were met and generally oversaw the day-to-day running of the project team. The secretary took the meeting minutes, noting any important points discussed, and deputised for the team leader in the event of absence. The individual marks were derived from the group mark, after peer assessment to acknowledge individual members

contribution and to ensure fairness. Pedagogical benefits of peer assessment to skills formation in group work is explained in Wilkinson & Lamb (2010).

RESEARCH METHODOLOGY AND METHODS

The research adopted quantitative and qualitative research methods in order to address the research questions. The research takes the position that individuals (as the unit of analysis) have their own perception of collaboration and preferred mode of communication with the others in the team (ontological position). These perceptions could be measured by asking team members (i.e. participants in the research) to express their opinion against a series of statements on a specific attitudinal scale. Data sets combining responses from the participants could then be analysed statistically to explore differences between categories (i.e. groups in the UK and Canada, gender, working experience, implementation phase), to generate new knowledge (epistemological position). To obtain quantitative data, a questionnaire was developed and distributed to participating students. The other goal was to identify a set of good practices for this type of implementation. In order to maximise impact, and provide sustainability for this implementation approach, the research aimed to create a set of 'guidance notes' for subsequent/future practitioners to follow if they also planned to conduct online collaboration with students. This required rich data detailing the students' and tutors' experiences, and using their perceptions of what worked and what did not during the intervention, to build a set of recommendations. In this case, the research position is that certain practices and interventions have an impact of the outcomes of virtual teamwork (ontological position). These practices and interventions are observable through feedback and observation of participants. This feedback and observation were then analysed qualitatively to generate recommendations (epistemological position). The qualitative data were obtained via focus groups, individual reflections, and observations. In combination, these two data sets provided a strong corroboration of the research findings, thereby verifying the results, further justifying this mixed methods approach, and satisfying the research objectives.

A questionnaire survey was conducted in the first two years of the implementation. In each year, the questionnaire was distributed twice: before (i.e. at the beginning of the first semester) and after implementation of design project (i.e. at the end of the second semester). The questionnaire survey sought: (i) background information (including course, gender, working experience), (ii) aspects of distance collaboration and teamwork (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 (provided in Fleming, 2015). For questions related to distance collaboration and teamwork (listed in Table 1) , 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'. A 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 (Garland, 1991). 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, 2015). A study by Leite *et al*. (2010) confirms the validity and reliability of measures of VARK learning style.

The questionnaires were distributed to all participating students before the project commenced. They were given around 15 minutes to complete it (three pages in total), and

responses were collected by tutors immediately. For the purpose of evaluating the consistency of the findings, this design project was repeated in two consecutive academic years. The first year data collection yielded 134 (n1) completed questionnaires, the second year 58 (n2) completed questionnaires. In total, there were 192 (N) completed questionnaires, which were subsequently statistically analysed using descriptive statistics and Chi-square tests obtained from SPSS software. Chi-square tests were used to identify if there were any significant differences between categories of respondents on their perception of collaboration and preferred communication mode. The initial findings with the smaller data set were presented in Soetanto *et al*. (2012a; 2012b). This paper presents findings of analysis from a larger data set which allows more robust conclusions to be drawn.

Table 1: List of collaboration and teamworking statements

Variable	Statement
V1	I need to check to see if the other team members have progressed their tasks as promised.
V2	I need to check the quality of work of the other members.
V3	In group work, I am exposed to higher risk of poor mark / performance.
V4	I feel more rewarded by working in team.
V5	The other team members make my job easier.
V6	The other team members are competent.
V7	The other team members are honest.
V8	The other team members complete work commitments on time.
V9	Communication over the internet is difficult.
V10	Face-to-face meeting is essential for a high performing team.
V11	Conflicts with the team at the other University can be resolved easily.
V12	Information has been communicated effectively.
V13	Information has been communicated via an appropriate medium.
V14	Decision making process has been effective.
V15	I need the other team to complete my work.
V16	Leaders exercise their duties effectively.
V17	I am clear about my role in my team.
V18	Team members are comfortable with each other.
V19	Overall, I am satisfied with working in my team.

In the third year of implementation, the qualitative method was adopted to identify good practices and then develop the guidance for online collaboration. Data were obtained and analysed in three groups of data sets, namely observational analysis of the recordings made by students of their synchronous meetings using 'GoToMeeting', focus group interviews in semesters 1 and 2, and analysis of personal reflections of the students. Participating teams were interviewed via focus groups, and required to submit individual reflections and one recording of team meetings via GoToMeeting, in each semester. Each recording lasted about 30 minutes to one hour and was jointly observed by the research team. A total of fifteen recordings (nine from the first semester and six from the second semester) were obtained. During the observation, the research team identified and discussed key issues arising from the observation. Due to the extensive experience of the research team, this not only enhanced the strength of identification and analysis, but also minimised bias. The findings were then grouped in several specific themes. A saturation point was achieved about half way through the fifteen recordings. The findings from the GoToMeeting observations were further informed by the analysis of focus groups and

individual reflections. These separate analyses enabled triangulation of the outcomes and provide supporting evidence for the guidance presented here.

RESULTS

Tables 2, 3 and 4 detail proportions of students based on their working experience, gender, and implementation phase categories. From a total of 192 responses, 92 responses were received from Canadian students, and 100 from UK students. Two-thirds (67.9%) had no work experience in the construction industry. In respect of gender, male students represent 59.2% and female 40.8%. The relatively even distribution of responses allows comparison between categories (e.g. comparison of responses between UK and Canada, male and female, working experience, implementation phase) to explore the relationship between categories and the collaboration variables.

Table 2: The number of participating students in each institution and working experience category

Institution	Students with working experience?		**Total**
	No	Yes	
UK University	67 (73.6%)	24 (26.4%)	**91**
Canadian University	62 (62.6%)	37 (37.4%)	**99**
Total	**129 (67.9%)**	**61 (32.1%)**	**190***

Note: * two students did not indicate their working experience.

Table 3: The number of participating students in each institution and gender category

Institution	Gender?		**Total**
	Male	Female	
UK University	76 (85.4%)	13 (14.6%)	**89**
Canadian University	33 (34.7%)	62 (65.3%)	**95**
Total	**109 (59.2%)**	**75 (40.8%)**	**184***

Note: * eight students did not indicate their gender.

Table 4: The number of participating students in each institution and implementation phase category

Institution	Implementation phase?		**Total**
	Phase 1	Phase 2	
UK University	45 (48.9%)	47 (51.1%)	**92**
Canadian University	52 (52.0%)	48 (48.0%)	**100**
Total	**97 (50.5%)**	**95 (49.5%)**	**192**

Table 5 presents significant relationships between (institution, gender, working experience, implementation phase) categories and collaboration variables. The analysis revealed some evidence of relationships between 'institution' category and two perceptions of distance collaboration, namely (i) 'In group work, I am exposed to higher risk of a poor mark (V3)' (p=0.051), and (ii) 'Face-to-face (offline) meeting essential for high performing team (V10)' (p=0.003). Further evaluation of the data indicates that Canadian students were more likely to feel that group work would not expose them to higher risk. However, they were likely to believe that face-to-face (offline) meeting was essential to achieve higher team performance.

Significant relationships were found between 'In group work, I am exposed to higher risk of poor mark (V3)', and both 'gender' (p=0.014) and 'working experience' (p=0.039) categories. An observation of the data suggests that female students and those who have previous working experience would tend to disagree that group work brings higher risk. Furthermore, there was a significant relationship between 'working experience' and 'communication over the internet is difficult (V9)' (p=0.008). Examination of the responses indicates that those who have previous

working experience tended to disagree to the statement that communication over the internet is difficult.

An evaluation of the relationships between implementation phase (pre-implementation in semester 1 and post-implementation in semester 2) and collaboration variables revealed that the students tended to agree that 'face–to-face meeting is essential for high performing team (V10)' in semester 2 (p=0.023). Perhaps, by the end of design project, the students feel that the issues encountered could have been better resolved through offline face-to-face meetings, if there is any means to organise this. However, the number of the students who disagreed with the statement 'I need the other team to complete my work (V15)' was significantly less in the post-implementation survey (p=0.002). Following their participation in the design project, a proportion of the students surveyed may have come to realise the need to work in team to undertake their work. This may be viewed as a positive improvement in the attitude to collaboration, and the project may have contributed to their enhanced appreciation of inter-dependencies between parties in the design process.

The analysis of VARK data suggests 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 the read/write mode. This difference was significant in year 1 (p = 0.014) and overall combined responses (p = 0.018) (see Figure 1). However, this difference was not significant in year 2. An analysis based on gender categories revealed a similar tendency with females preferring visual and kinesthetic modes, and males preferring the read/write mode (year1, p = 0.067; overall, p = 0.069). This may be because the majority of architectural students in the Canadian university were female, and the majority of civil/structural engineering students in the UK university were male (see Table 3). There is no relationship between both working experience and implementation phase, and VARK categories in the first, second and combined years.

Table 5: Significant relationships between categories and other variables

Category versus Variable	Probability value
Institution vs. "In group work, I am exposed to a higher risk of a poor mark" (V3)	0.051
Institution vs. "Face –to-face meeting is essential for high performing team" (V10)	0.003
Gender vs. "In group work, I am exposed to a higher risk of a poor mark" (V3)	0.014
Working experience vs. "In group work, I am exposed to a higher risk of a poor mark" (V3)	0.039
Working experience vs. "Communication over the internet is difficult" (V9)	0.008
Phase vs. "Face–to-face meeting is essential for high performing team" (V10)	0.023
Phase vs. "I need the other team to complete my work" (V15)	0.002
Institution vs. VARK (year 1)	0.014
Institution vs. VARK (year 2)	0.705
Institution vs. VARK (years 1 and 2 combined)	0.018
Gender vs. VARK (year 1)	0.067
Gender vs. VARK (year 2)	0.531
Gender vs. VARK (years 1 and 2 combined)	0.069

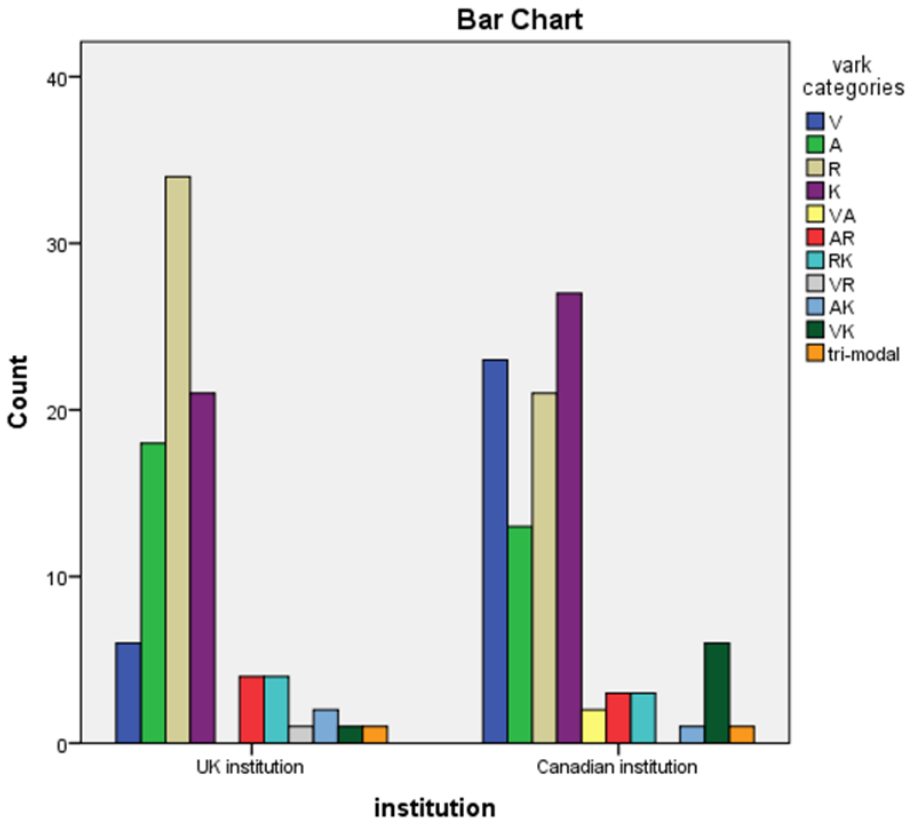

Figure 1. VARK profile for institutions (years 1 and 2 combined)

DISCUSSION

The findings highlight the significance of perceived risk, face-to-face meetings, internet communication, and perceived dependency on one another. Particularly, it is worth noting that the perception of risk was found to be significantly different in three categories, namely institutions/ disciplines, gender, and work experience. When an individual is going to undertake a particular task, in their mind they consider the personal risk and reward from undertaking the task. The perceived risk and reward also influences the level of trust between members in a virtual team (Zolin *et al*., 2004). This perception determines their behaviour and commitment, and ultimately the performance of a virtual team. Architecture students in the Canadian university perceive less risk in group work than their civil/structural engineering students do in the UK university. The same finding was found with female students who represent the majority of architecture students, and those who have previous working experience. Architecture students also perceive a need for face-to-face meetings, more so than their counterparts. 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 design studio, which familiarises them with group learning and a higher level of face-to-face interactions. The process facilitates the development of trust, hence the perceived lower risk associated with group work. Those with previous working experience might tend to realise the need for group work and communication over the internet to deliver their projects, and therefore this mode of working is often not just necessary, but essential for collaboration.

The difference in the preferred communication modes used by the two professions raises an important question; to what extent has this difference been formed by disciplinary training? To address this question, a comparison of the preferred communication modes of the general

population can provide a reference from which an inference may be drawn. The VARK website, which has been online since 2001, can provide a comparison with the general student population. Based on online responses from around 80,000 students from different levels (including universities, colleges and high schools), Fleming (2015) found significant differences between males and females in their preferred communication modes with men having more kinaesthetic responses and women more read/write responses. Similar to the finding of this research, he also found that subject discipline can influence VARK preferences with those studying graphic design and art subjects preferring visual modes of communication. If the responses in this research demonstrate the same tendency, the finding suggests that training in subject disciplines can influence students' preferred communication mode.

The findings from the quantitative data analysis point towards the need to address perceived risk of distance collaboration in virtual teams, and to raise awareness of different preferred communication modes between members from different disciplines. The perceived risk may be lowered if the members have experienced a virtual teamwork process in their previous work assignment. If they have not had this experience, familiarisation with the virtual teamwork process before they embark on the assignment could also be beneficial. In the group learning setting, the tutor could facilitate familiarisation by providing guidance throughout the duration of the project, and if necessary act as the mediator to resolve any relationship issues/ conflicts which are beyond the means of the learning groups. The mediator was found to be an important factor to enable effective process of virtual collaborative learning (Soetanto *et al*., 2014). However, it is important that tutors should, as far as possible, let students resolve issues by themselves, because experiencing group dynamics, and managing content and relational space (Leinonen *et al*., 2005) are an integral part of learning in the virtual team. It is also important to appreciate different ways of communicating design information. Sketches, drawings and 3D digital models may be used as media for communication; however they may not be able to support the breadth of activities in collaborative interaction in a virtual design team. For example, Dossick and Neff (2011) suggested that current building information modelling (BIM) technologies do not fully support knowledge synthesis during collaborative interaction as they appear to be fixed and immutable. They argued the need for active, informal and flexible media to support joint problem solving in the virtual team. Notwithstanding media requirements, this seems to suggest that the use of multiple communication modes (e.g. discussion in online meetings, exchange of emails, 3D BIM models) may benefit collaborative interaction in the virtual team. Similarly, Dossick *et al*. (2015) identified a gap of knowledge in the distributed design work of the virtual team and how to best support the virtual teams. The following section presents guidance to support international collaborative design projects, which aims to help to lower the perceived risk of collaboration in virtual teams.

GUIDANCE FOR IMPLEMENTING COLLABORATIVE DESIGN PROJECTS

There is very little evidence that guidance for implementing a collaborative design project exists. Several scholars have published lessons learnt from their implementation in their classes, but these are somewhat piecemeal and do not cover activities comprehensively. This is mainly due to the variability of implementation (Solnosky *et al*., 2014). One recent example, Lee *et al*. (2013) provides guidelines for integration of BIM in construction engineering and management education. It includes technical and management skills which could be introduced by integrating BIM in the curricula. However, it does not fully cover detailed operational aspects of collaborative design project implementation. It also does not provide practical guidance on the 'act of collaboration' in an online environment.

The guidance below was developed mainly for BE educators who are contemplating, or about to implement, collaborative building design project within their programmes of study, involving international partner(s). The guidance not only provides practical advice to implement a

collaborative design project based on the experience of the research team, but also good practice in collaborating online, which were synthesised from the data collected during a course of one academic year.

The aim of the guidance is to help BE educators and learners to develop strategies to achieve a high level of collaboration awareness, and hence to enable effective online collaborations. The strategies were structured in several themes arranged in a hierarchical order, where one theme provides support for the level above it. This hierarchy is diagrammatically presented in a pyramidal model, divided with horizontal slices which each represented each theme. The pyramidal model is shown in Figure 2. The model and complete set of guidance can be seen in http://bim-hub.lboro.ac.uk/. It is not intended to be comprehensive or directive, rather to articulate a set of guiding principles, which can be used in the design and implementation of students' learning activities.

Level 1: Satisfying institutional requirements and aligning with professional guidelines

Level 1 focusses on institutional and professional considerations for facilitating the implementation of an international collaborative design project. It comprises considerations of implementing institution and professional body requirements on the programme/course. It advises on required adjustments to the existing institutional embedded practice and challenges of these adjustments might encounter. It also covers details of various operational aspects, including choosing collaboration and educational technologies, prior skills of participating students, organisation of consultative meeting between tutors and students. Level 1 sets up the ground rules for the activities, considering the context in which it is to be implemented.

Level 2: Designing activities for online collaborative design

Level 2 discusses how to run a collaborative design project across multiple institutions, and to develop the design brief, learning and peer assessment requirements which are consistent and fair for all participating students. Levels 1 and 2 may vary according to subject disciplines, but this has been compiled specifically for BE subjects. The remaining levels relate to generic skills that apply to any collaborative design activity that students may undertake.

Level 3: Support for collaboration

Levels 3 and 4 will be relevant for any collaborative project, whether offline or online. Level 3 looks mainly at the support needed by students when engaged in collaborative activities as part of the curriculum. It is assumed in this case that teams from more than one university are studying different modules (each at their own university), but have a collaborative exercise as part of those modules. This level underlines the need to support the students to maintain good communication throughout the project. It also touches on the use of compatible software.

Level 4: Skills for collaboration

Level 4 looks at the skills that students need to acquire to conduct collaborative activities effectively, whether offline or online. The question of how many of these to directly address with students, and how many are best left for them to learn by experience remains open. It is suggested to raise them as 'things to be aware of', then observe students to see if failing to acquire them is particularly impeding their ability to conduct the activity, at which point some remedial additional seminars on the skills could be implemented. These skills are, in general, applicable to any subject discipline. They are also applicable to collaborations that are intra-organisational (although inter-disciplinary) only. Inter-organisational and international collaborative skills are addressed in the online section, since inter-organisational and international collaborations are likely to be conducted online.

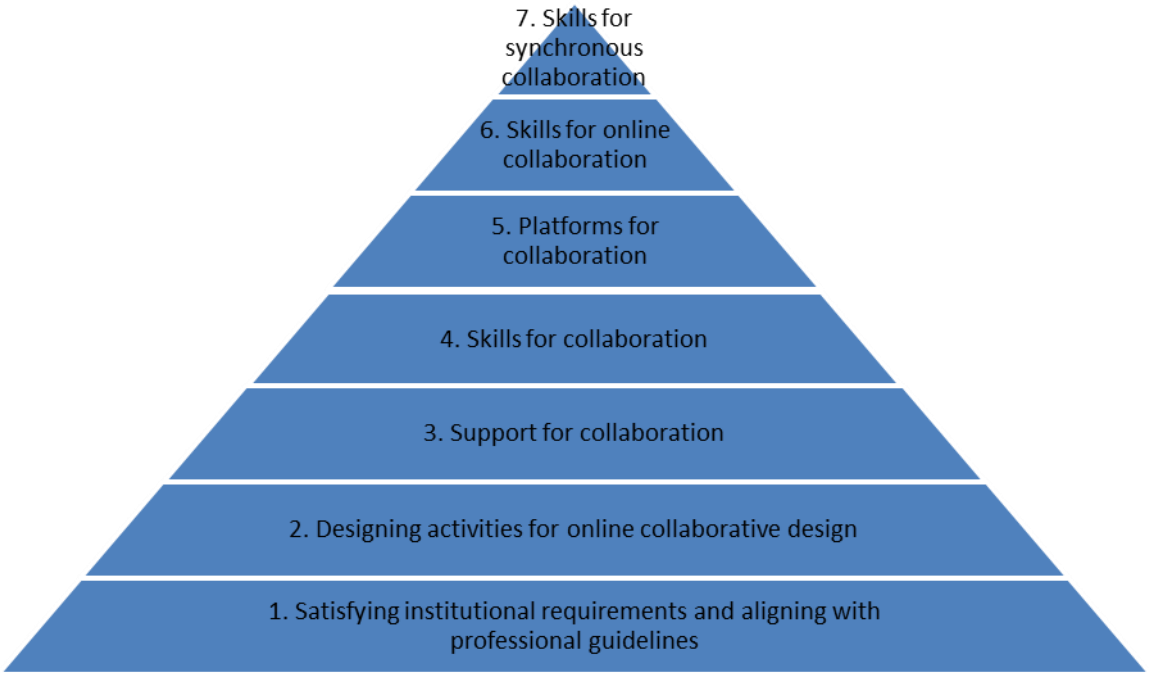

Figure 2. Pyramidal model of guidance for an effective online collaborative design project

Level 5: Platforms for collaboration

Levels 5 and 6 refer specifically to projects that take place online, when teams are working collaboratively in a virtual environment. This is also the point at which many of the skills of working on inter-organisational and international collaborations can be acquired. Level 5 records the use of technologies by participating students and requirements of hardware and software to enable collaboration. In the project reported here, students were free to use any platforms they wished for their asynchronous working, but were assigned GoToMeeting for their synchronous meetings. All students used email for lengthier communications, most used Dropbox for sharing and storing information, and all used Facebook for communication that required a faster response. The skills they acquired to use the technologies are covered in sections 6 and 7.

Level 6: Skills for online collaboration

Level 6 looks at the skills the students learnt to apply when moving to an online environment. Many of these appear to be generic skills that would need to be used in any collaborative activity. However, it emerged that the students, although all had worked in teams before, had not acquired these skills. None had experience of virtual teamwork before beginning the project. This was because of the degree of contact they had with other members of their teams when working face-to-face. This meant that these previous collaborations could be affected easily on an *ad hoc* basis. It therefore needs to be noted that, even if the students are familiar with offline collaboration, some skills will need to be acquired when they move to an online environment. Also in reality, most of the challenges that come with inter-institutional and international collaboration are introduced at this point, as the face-to-face collaborations the students were exposed to will be intra-organisational only.

Level 7: Skills for synchronous collaboration

The skills needed for successful synchronous online collaboration are additional to those, which are routinely used in offline team-working. Level 7 is specifically for these additional skills required when activities take place synchronously, usually during videoconferencing. Some skills

appropriate only to international collaboration can also be acquired here. In the project reported in this paper, students used GoToMeeting, but the skills considered here are independent of the platform used. Guidance at level 7 focuses on making the students aware of the basic norms of behaviour that can be adopted in online meetings. Some of the skills may be seem at first to be self-evident, but in the project, the students were often unaware that they needed them at the start of the collaborative process and sometimes failed to acquire them by the end. Whether the tutors choose to instruct students at the start, or allow them to discover the skills for themselves through trial and error, is a matter of judgment. To be effective, learning from experience requires opportunities for reflection, which can be time-consuming. Consequently, those working on a short timescale may need to fast-track the learning process using the guidance materials we have provided.

However, some of these behaviours should be regarded as essential as they are necessary to meet inclusivity and equality protocols of institutions, and it is appropriate to inform students that they must be used when interacting with each other. As the students became familiar with the use of the GoToMeeting platform, several changes in behaviour became apparent, e.g. they adopted better meeting management techniques, they became more fluent in using the technology for their own purposes, their interactions with each other were faster and clearer and they presented a more positive online presence. In part this was because tasks and roles become clearer as a project progresses, but in part this was because the students became more experienced with how to conduct themselves online and confident at working in a virtual environment.

CONCLUSION

The application of a collaborative design project in the BE curricula is not new. However, the approaches, object of design, supporting technology used, location, discipline composition and training of participants in the implementation of this activity in the BE curricula vary considerably. Consequently, the outcomes and impacts are difficult to replicate outside the context where it was evaluated. A review of literature suggests that relatively little is known about the elements that determine and influence virtual team performance (Lee-Kelley & Sankey, 2008; Algesheimer *et al*., 2011). This has led to the need for a greater understanding of factors influencing multi-disciplinary virtual team interaction and collaboration (i.e. risk, trust, learning style). Furthermore, previous implementations have not provided sufficiently comprehensive lessons learnt, and therefore, meaningful guidance on how to implement multi-disciplinary and –institution international collaborative design projects is arguably absent. To address this gap in knowledge, the paper presents the key findings from a three-year international collaborative design project implementation in UK and Canadian universities, including the analysis of primary data on the perception of collaboration and preferred communication modes, and the guidance for effective practice in an international collaborative design project. The main target audience for the guidance is BE educators who are contemplating, or about to implement, a design project within their curricula, involving international partners. However, those participating in online collaboration can also benefit.

The findings show the effect of disciplinary training on the perceived risk of collaboration and preferred communication mode. Familiarity with team-based collaboration and studio-based learning where frequency of in-person meetings is high, might have facilitated the development of trust between colleagues, and reduced perceived risk. Higher perceived risk is not conducive to successful collaboration as individual members can decide to take actions to protect their own interest and be only partially committed to group work. Consequently, the benefit of co-creation of design, which can provide an optimum solution to the problem, cannot be obtained. In the context of group learning, tutors should consider mechanisms and activities to reduce the perceived risk of collaboration by, for example, providing guidance, taking on a mediating role (if there is a need

for intervention), encouraging social gatherings, or the use of social media (if face-to-face meetings are impossible). This informal communication can help the development of trust (Strahorn *et al*., 2015) and benefit knowledge synthesis in joint problem solving (Dossick & Neff, 2011). Following their participation in the design project, the students realised a higher perceived dependency on others in undertaking their work. This suggests a positive impact on their attitude to collaboration.

Assuming that the findings of Fleming (2015) are valid and represent the population of those in education, our findings suggest that training in the subject discipline can influence the preferred communication mode of individuals. It is worth noting that a mismatch of preferred communication mode amongst individual members from different disciplines can lead to inaccuracy of information exchanged, ineffective and inefficient process, and hence sub-optimum design solutions. In the worst case, mismatch causes conflicts between members of project team (Fleming, 2015). This highlights the need to raise awareness of different preferred communication mode between members of different disciplines. Given the challenge involved in the process of knowledge synthesis, the use of multiple communication modes (e.g. discussion in online meetings, exchange of emails, 3D BIM models) may benefit joint problem-solving in a virtual team. While it may be unreasonable to expect that members of project team should have the same tendency for certain communication modes, this finding reiterates the need for integration between BE disciplines, which is an important message for stakeholders in BE education. In practical terms, BE students should be exposed to subjects beyond traditional disciplines, giving them a wider and richer range of skills required to work in the 21st century. These skills will enhance their appreciation and understanding of the requirements of built facilities beyond their disciplines. In the long term, this process will help to dismantle the 'disciplinary silos' which have hampered the performance of industry for centuries. For other stakeholders in the BE sector, the findings of this research suggest the need to reduce perceived risk in virtual collaboration and to use multiple modes for communication of complex information in design and construction process. The perceived risk may be reduced by better understanding of the collaboration process, and by having an early consensus on planned activities involved. To reduce the perceived risk, trust between team members is essential.

Several limitations and the need for further research are detailed as follows:

- Although the overall findings were found to be significant, there were discrepancies in the findings between the first year (as presented in Soetanto *et al*., 2012a; 2012b) and the second year of implementation (see Table 5, non-significant findings of VARK preferences). This inconsistency suggests the need for further data collection to develop a more complete pattern of VARK preferences.
- The findings on preferred communication modes suggest the need for further research to explore the optimum utilisation and combination of communication modes to achieve knowledge synthesis in the virtual collaborative building design.
- The guidance presented in this paper serves as a means to share the authors' experience to help BE educators and enhance their practice. It should be trialed in different contexts and further developed based on the evaluation of the outcomes.
- Using students as participants brought several advantages, notably higher response rates 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 BE professionals, a generalisation to industry professionals should be drawn with caution, as they would have acquired more experience and other influences in the workplace.

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