EXPERIMENTATION OF COLLABORATIVE LEARNING FOR CONSTRUCTION ESTIMATING

Olatunji Oluwole Alfred, Associate Lecturer, oluwole.olatunji@newcastle.edu.au
Willy D Sher, Senior Lecturer and Assistant Dean Teaching and Learning, willy.sher@newcastle.edu.au

ABSTRACT

The success of project documentation and implementation depend on an effective collaboration within project teams. However, fragmentation has been a major concern in the industry for many centuries. Evidence suggests that this phenomena challenge weakens value integration among project teams; and regrettably, most academic programs are still tailored to service this limitation. As BIM is driven by integrative skills, this paper describes the formulation of an academic course for a multidisciplinary and integrative study of an estimating course. Specifically, it is targeted at a class of undergraduate students with backgrounds in project team disciplines – architecture, quantity surveying, structural and services engineering. The focus is to engage students in collaborative learning such that they are able to develop technical briefs, design tender programs, estimate and analyze tenders. A model for formulating groups and group assignments is proposed. In the end, study outcomes reveal that students will be multi-skilled and better team players than those under fragmented learning environments. Conclusions are drawn on curriculum development for integrative innovations such as BIM and virtual project management.

Keywords: blackboard learning system (BLS), building information modeling (BIM), collaborative learning (CL), estimating and teamwork.

1. INTRODUCTION

Building information modeling (BIM) is gradually changing the theory and practice of design and construction paradigms. Existing evidence in literature suggests this phenomenal change is predicated on the vulnerability of entity-based CAD applications. These applications, according to (Winch and Deeth 1994), deploy unintelligent features such as lines, splines, arcs and circles; and do support process fragmentation. Many studies have also outlined how the construction industry has been subjected to systemic limitations as a result of fragmentation and product-based design. (Kalay 1998) opine that fragmentation is a major disincentive to certain attributes that drive client-concentric goal, especially regarding defining appropriate methodologies for achieving specific performance milestones in project design, development and operations (PDDO) systems. This heart of these challenges therefore is that project teams should collaborate more with interoperable applications, including ability to combine desktop and discipline or project-specific applications to achieve project goal; and with appropriate attributes as and when due.

An extensive study by (Aranda-Mena et al. 2008) concluded that many potential deliverables of BIM innovative ideals may not be realized regardless of the level of technological sophistications which may have be invested in BIM unless certain behavioral attributes are met. The case studies used in this study by these authors specifically underline willingness of team players to collaborate effectively as a major driver of project success; and not skills, management capabilities, finance or technologies which have been rhetorically over-estimated in some studies. Elaborating further on the role of collaboration in successful project delivery, (Olatunji et al. 2010a) argued that collaboration is an essential component of behavioral framework in BIM which has not been given adequate attention in literature in consonance with building capacity to enhance process re-engineering in the industry, especially in terms of skill and technology, towards effective deployment of BIM. Although, other studies also identified collaboration as a success factor in BIM, however this is only limited to macro level of project implementation and some limited aspects of design theories (Gül et al. 2008). Meanwhile, applicability of BIM as a tool is not limited to design, but rather include simulation, construction and operational life of constructed facilities (Ballesty et al. 2007; Heesom and Mahdjoubi 2004). It is therefore expedient to definitively explore how this could be implemented in controlled multi-disciplinary learning environments where extensive matrix of study scenarios are involved e.g. multiple mode of learning, difference in disciplinary background of students, course design and different types of degree and divergent learning outcomes, and so on.

Interestingly, like the conventional construction industry where fragmentation is a major issue, pedagogical support for generating innovative skills through integrative learning is still problematic. This is because most teaching curricula in this subject are not constantly updated to keep pace with changes in the industry, or at best may, cannot represent everyday innovative practices that are based on common industry challenges. Apparently, the most vitally important achievement of studies in this direction has been on improving interactivity between students and teachers and, triggering teamwork amongst student to achieve specific learning outcomes (Gül et al. 2008). (Williams et al. 2004) have identified the limitations of normative assessment of group work assessment. These were hinged on students' divergent commitments and priorities, and limitations in strategic methodologies for designing and delivering online multi-disciplinary courses, especially those that involve undergraduate students with potential relevance in handling BIM implementation in the future. This paper proposes a collaborative learning model of a particular estimating course via mixed mode teaching delivery system for a fairly large number of students with backgrounds in engineering, architecture and construction management disciplines.

2. COLLABORATIVE LEARNING

Teamwork and collaboration are constantly used in construction literature as though both are synonymous. In many cases both have been used to convey relativity in the interaction between actors in a group to deliver specific project outcome. However, (Baiden et al. 2003) argued that teamwork is not exactly the same as collaboration. According to Cambridge Online Dictionary (www.dictionary.combridge.org), teamwork is interpreted as '*when a group of people work well together*'. Conceptualizing this in construction perspective, (Ingram et al. 1997) argued that teamwork could extend to meaning a group of people that work well together to achieve a common interest. Meanwhile, project teams are vulnerable to different types and levels of biases. Past studies have shown that ethical issues, inadequacies in the integration of disciplinary values and non-interoperability of data exchange platforms are potential distractions that trigger fuzzy risks amongst competing interests. For instance, a project team may decide to target a common interest which may not prioritize clients' expectations or maybe in the end sabotage project goal. Some indices of project failure arising from the vulnerabilities of conventional dynamics of teamwork are detailed in (Office of Government Commerce (UK) 2005). This perspective also agrees with (Kometa et al. 1995) where the authors clearly concluded that construction clients are in better positions to drive their project goals as there may not be an end to project teams' vulnerability in project delivery processes unless clients are involved right from the beginning to the end of the project.

On the other hand, Cambridge Online Dictionary defines collaboration as *"when two or more people work together to create or achieve the same thing* {project goal}*"*. The hallmark of collaboration in BIM environment is that players are willing and committed to contributing information to project repositories and to adopt appropriate strategies to drive project conceptualizations in line with project goals at all time. This include ability to adapt to and use data in forms that are useable to other players in the team and can extend information in its simplest forms to all levels of users. (Sher et al. 2009) have identified this as part of the vitally important skills that are required to drive project success as the industry heads towards deploying innovations of virtual reality in project development processes.

Therefore, there are marked differences between teamwork and collaboration in virtual world which must be reflected in teaching and learning for BIM to achieve its goal through teaching. For instance, in teamwork, fragmentation compromises achieving project goal whereas collaboration is not an option for negotiation as all players are fully integrated. Additionally, as teamwork is behavior-based, the emphasis of collaboration is not limited to tools for product development environments and system dynamics other than assigning responsibilities and motivating or incentivizing teams to work together. Rather, collaboration entails the combined deployment of goal-concentric behaviors, appropriate tools and platforms for integration, interactive environment for managing development processes.

Although, most pedagogical structures are fragmented while BIM teaches integration, teamwork is not new to teaching and research theories in construction education. According to (James et al. 2002), group learning has served the education industry in stimulating specific generic skills sought for by employers, as well as improve students' interaction and overhaul the quality of study outcomes. (Schmidt 1983) outline this as a vitally significant attribute of problem-based learning for would-be professionals. Some of the benefits of group learning include:

i. Exposure to, and understanding of, team dynamics and leadership skills.
ii. Improvement in players' cognitive and analytic skills through objective interaction, peer-evaluation and openness to resources from other members of the team.
iii. Possibility of understanding the benefits of conflicts, as well as how to endure, manage and resolve critical thinking, criticism and compromise.
iv. Ability to develop methodologies for managing flexibility in learning outcomes.
v. Focus on group's common goal, and possibility of incentivizing self-esteem when study requirements have been met.

The procedure for setting up effective study groups have been nominated in many studies. (Davis 1993) suggests that study groups should be small, structured to accommodate adaptive roles and focus on specific assignment goals. Another role of the teacher is to provide clearly defined aim of each group and the roles of each players in the team. Most effective study groups will have:

a) An organizer: a character who facilitates group convergence, discussion triggers, discussion schedules and keep group interaction on focus
b) A plant: a self motivated character with exceptional skills to service group activities with information in relation to critical evaluation of assessment requirements.
c) Record keeper: someone to keep records, collate and report summary of group activities, action plans and logs
d) Investigator: someone to explore the activities of other competing groups, help the group to gather any required information from specific sources and execute other assignments that may be given.
e) Moderator: liaison with assessor or tutor and a regulator of group activities

3. INTEGRATED COURSE DELIVERY: BLACKBOARD LEARNING SYSTEM

Online course delivery system (OCDS) is popular in many countries. In Australia, blackboard learning system (BLS) is used in many Universities for mixed-mode delivery of courses. Its aims include to reach specific target participants without geographical limitations and allow study participants with commitments other than full time learning to have flexible access to educational resources. One of its major attributes therefore is the provision of platforms for interaction between mature students – those with a range of industry experience, and first-hand learners who have got limited practical exposure on issues being raised in the subject. An example of course design for collaborative learning on BLS has been demonstrated in (Sher 2004). The study focuses on peer assessment of students on design and construction of a reinforced concrete lintel as the main assessment item of an integrated learning course. In an integrated learning course, students often come from different discipline backgrounds like engineering, construction management and architecture. There has been many cases where exchange students from other universities from different parts of the world have taken part in this program. Some of the benefits and attributes of BLS can therefore be summarized as:

- **Online enrolment:** students are enrolled into the course once specific requirements have been met. Identities such as the number of courses a student is enrolled in, age, sex, background are kept mainly for administrative purposes. Once enrolled, course participants (course coordinator, tutor(s), observers and students) can communicate and access course resources once BLS is made available to them.

- **Discussion forums:** BLS allows course handlers to create online discussion forums both for groups and for the entire class. In many cases, discussion triggers, such as specific project scenarios, could be introduced to course participants for debates several times before the end of the study term. Interactions between participants can be monitored both from posts made by each contributor to the discussion forum and through captured data on course participants' access to the BLS. One major advantage of this attribute is that students can create question threads, asks specific course-related questions, respond to questions from others, upload files, share personal opinion/experience and benefit from others'.

- **Lectopia:** There are repositories in BLS where weekly lectures and tutorials are kept and students are at liberty to revisit or repeat class discussions at their convenience. Audio-visuals and presentation resources are can be viewed, downloaded and quoted many times until class participant's access to the BLS expires or has been revoked.

- **Online tests:** Many forms of tests can be conducted on BLS including multiple choice, open ended, mathematical, essay, quiz bowls, random blocks, randomized assessment from a pool of questions among others. Tests can be marked automatically and students can received both their marks and feedbacks once a specific test has been completed.

- **Turnitin originality index:** Major assessment items can be made to conform to more structured formats than online tests. This is because they carry more assessment weightings. The purpose of the mechanism is to allow students to submit their assignments online. This can be in multiple files formats and applications. They may also be without file size restrictions unlike e-mails and similar communication systems. When students submit their assignments, texts in submitted files are compared automatically with several forms of existing materials on the internet including past submission either by the same student or others' within and outside the school, websites, journal articles, posters, magazines, online blogs, conference materials, advertorials and other forms of academic or technical materials. An index on originality is then issued to show similarities between the new submission and other materials that already existed.

- **Peer assessment:** Through interactive learning, students within a group can assess the contributions of one another, and extend same to the course handlers. Although, may not be free from limitations, students may derive more satisfaction and confidence when they are involved in self or peer assessment once marking rubrics have been provided as guides.

- **Reflective journal:** This is described by (Blaise et al. 2004) as a new order of learning in the 21st century where students can exhibit and improve on critical refection on self knowledge and several trigger readings. Blogs can be created on BLS to enable students review rationales in trigger readings they are provided with, compare their opinions with others' perspectives, relate a reading to another reading, and to specific learning objectives and study outcomes. It is also necessary to do same for immediate and remote impact of such readings on their learning career. Reflective journal is not a substitute to actual teaching, rather an opportunity for students to acquire additional information on a subject being covered and subject same to critical analysis.

4. DESIGNING A COLLABORATIVE COURSE ON BIM ESTIMATING ON BLS

Course design starts with the identification of scope of study as stipulated in standardized synopsis of a program. It involves defining the expected learning outcomes and setting-up effective assessment methods for all assignment items. To avoid ambiguity, a guide on designing a course and the principles of assessment are listed in (Astin et al. 1996). Although, this may vary from institution to institution, Figure 1 below outlines some of the variables of collaborative course design that can work with BIM estimating. The bottom line is that for the industry to generate the next generation of industry practitioners who will be able to apply BIM concepts, both the design and theory industries need to encourage tactical and strategic development and application of collaborative skills. Interestingly, BLS as a tool, and of course most university regulations, encourages integrative learning which involves different learning matrices e.g. distance education, on-campus education, online learning system, problem-based and adaptive learning structures, multi-disciplinary students' background and class composition, and reflective learning system. Therefore, the following steps is relevant in creating a course on collaborative learning towards cost estimation of BIM projects:

(A) **Learning outcomes:** At the end of the term, students should be able to (i) articulate clients requirement in a project (ii) understand ethical concerns in estimating and tendering (iii) recommend and have confidence in managing a tender process, and; (iv) develop an effective estimate for a building project

1. Introduce students to the nature of clients' requirements – Necessarily, this could be ambiguous, complex, infeasible, but students should be required to focus on functionality of project components, quality, cost, time and limited health and safety risks.
2. Discuss project development processes – The scope of this learning aim could be limited to from feasibility to tendering and contract documentation. Students will particularly show interest in what BIM potentially offers which are different from what fragmented attributes can offer e.g. visualization, simulation, auto-quantification, robust data underlying design components and so on.
3. Students also need to know different forms of tender and the applications of electronic documents management systems (EDMSs), including e-tendering and offering of quantified drawings directly to contractors.
4. Ditto factors that affect costs – complexity, project risks, labor and material requirements, speed of execution etc; sources of costs data - industry databases, market surveys, manufacturers' catalogues, marketing portfolios of companies etc; compilation of cost items that form pricing elements of a bid – materials, labor, plant, profit and overheads; and cost interaction with time.
5. Also important is the conceptualization of project costing methods – cost planning (e.g. elemental and comparative), schedule of prices, costs modeling and bid validity, negotiation and finalization
6. Articulate major items of tender documentation - call for/and invitation to tender, form of tender, drawings, specifications, condition of contract, Bill of Quantities, Schedule of Prices etc
7. Introduce students to ethical concerns/expectations in tendering across discipline

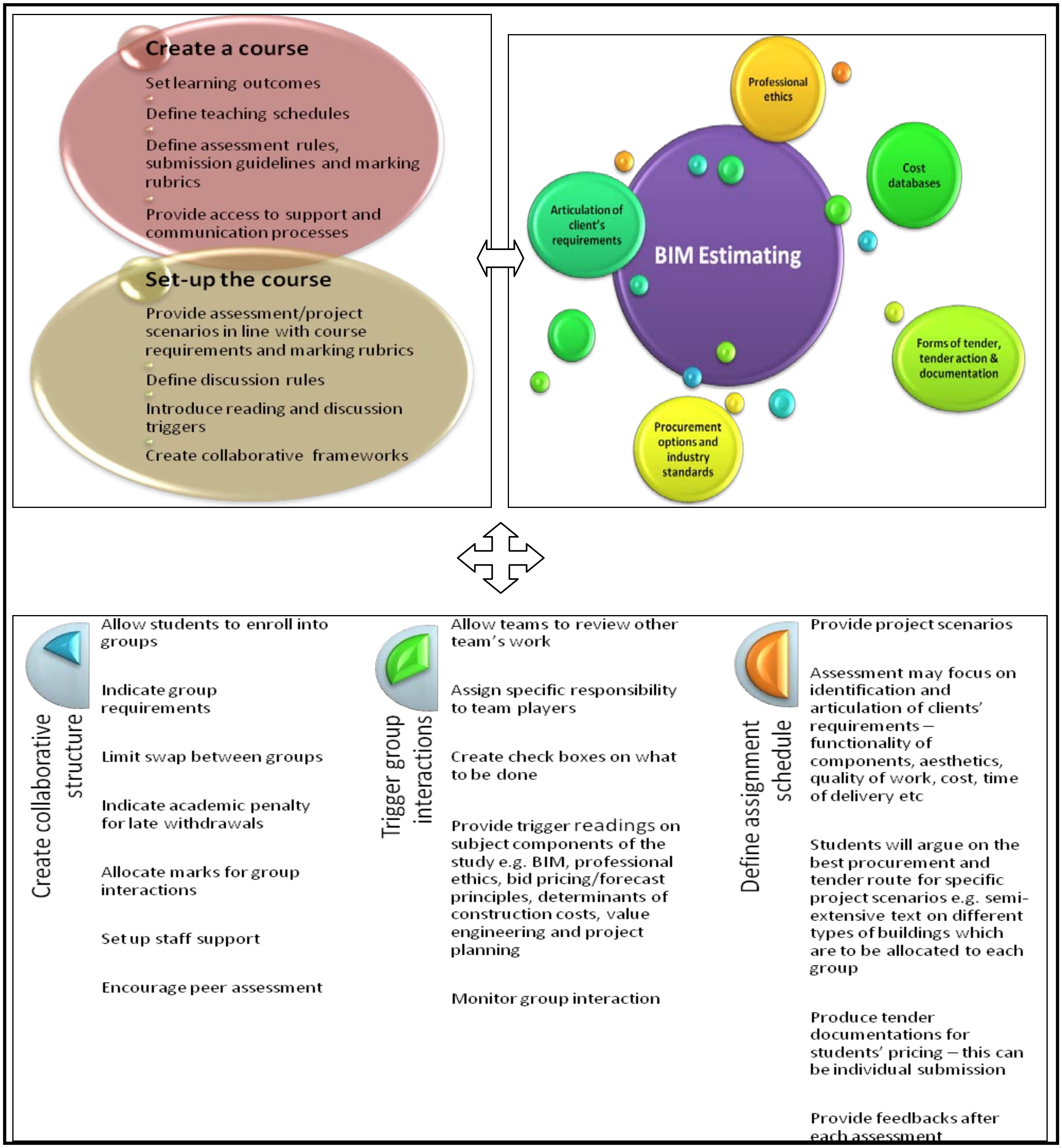

Figure 1: collaborative course design model for BIM estimating

(B) **Assessments:** This could be multiple – multiple choice, report writing, reflective journal and tender pricing

8. With a maximum of 5 members in a group and project scenarios on different projects spread between groups, students will be able to reflect upon available facts and determine (a) what the clients requirements are (b) identify ethical concerns (c) the best tendering procedures for the project (d) how to assess project risks and contractors capability (e) determine the best cost for the project.
9. Items (a) – (c) can be assessed as the focus of collaborative learning between the students, while items (d) and (e) can submitted individually.
10. Reflective journal can be targeted at ethical issues innovative tendering processes.

(C) **Feedback:** After each assessment, feedback is necessary for each student or group according to course requirements and as detailed in marking rubrics for the course.

(D) **Progress Monitoring:** There are tools on BLS that report students' participation. Students' participation could be in different ways: while some students would only want to understand assessment requirements for the course and get their head around this at the beginning of the learning period, some have other commitments that make then unavailable for most of the time. As such they would visit the course website few times throughout the duration of the program – this may be to download course materials once before assessment is due, submit assessment and check result. Apart from these groups, there are students who would show interest in following the course through from the start to the end, including making contributions to their group and other course discussion. Although, could be difficult, some of the challenges the course design must address is to adopt appropriate methods for stimulating students' engagement regardless of their commitments and biases.

(E) **Addressing problems:** Many problems may arise during collaborative learning in mixed-mode course delivery. Some students within the group may withdraw before the end of the course thereby increasing pressure on other group members to deliver the learning outcomes with insufficient members. In most cases, it is not just the number of students in the group that matters but the role any withdrawee may be playing in the group and the impact that may have on the final outcome of the group. To address this, the course designer has to define functionality threshold for a group in relation to specific tasks of the group. And, when the number of students in a group drops below the threshold, other members of the group are allowed to join other groups, report what they have done in their previous group(s) and their contributions to the achievement of the new group. There could be a limitation and strict conditions on group swaps. Additionally, there could be problems with data being contributed by some member of the group. This could be in terms of quality, accuracy, relevance, originality and pattern of presentation. One way to address this is for course handlers to monitor and support group activities. Groups can also gain supports by reporting their challenges on discussing forums where others can contribute and help them out.

(F) **Understanding trade-offs between teamwork in conventional course design and collaborative learning with specific focus on BIM:** Conventional courses on estimating are designed in the different ways; but most importantly to engage students' standalone capabilities. An example of a well outlined training and teaching design has been articulated by (Scott 1980). This often including testing students' critical thinking on construction processes and challenges, numerical skills on manipulating design data and strong communication skills to carry client and other professionals along. However, most findings in recent estimating research have underlined the need for objectivity in estimating processes. This is because, in practice, estimators have to relate with others; not just colleague estimators but with other professionals and people with different degree of experience and forms of training. Moreover, while most past estimating courses emphasize quantity measurement and business concerns on estimating protocols, some recent studies have shown that dynamic situation in construction processes may render standalone estimators redundant (Olatunji et al. 2010b). The idea of collaborative learning therefore is to stimulate interaction between students and allow them to share data and study interests, and in the process identify good opportunities where their studies can be applied.

5. CONCLUSION

The design and construction industries have witnessed several innovative changes recently. Some of these changes have been identified and recommended for integration into curriculums in (Kajewski et al. 2002). However, these changes have not remained static either; this is because after this report, the industry is being challenged by BIM adoption, especially how to effectively generate skills that might service potential changes that BIM may trigger. This paper has identified collaborative learning as one of the best ways to go in implementing changes in teaching curriculums in favor of BIM. Specifically, a mixed-mode problem-based learning model have been outlined with step-by-step guide on designing an interactive course for BIM estimation. The model requires students from different discipline backgrounds and experiences to work together in teams through BLS facilities and fulfill an undergraduate course requirement on Estimating and Tendering. In the end, collaboration within and across team will stimulate a better chance of integration between students and will generate clearer direction for future steps for students - this is what fragmented learning environments have grappled to achieve in over decades (Blaise et al. 2004).

REFERENCES

Aranda-Mena, G., Succar, B., Chevez, A., and John, C. (2008). "BIM National guidelines and case studies." Cooperative Research Centres (CRC) for Construction Innovation (2007-02-EP), Melbourne, Australia.

Astin, A. W., Banta, T. W., Cross, K. P., El-Khawas, E., Ewell, P. T., Hutchings, P., Marchese, T. J., McClenney, K. M., Mentkowski, M., Miller, M. A., Moran, E. T., and Wright, B. D. (1996). "9 Principles of Good Practice for Assessing Student Learning." <http://ultibase.rmit.edu.au/Articles/june97/ameri1.htm#AAHE> (21st June 2010).

Baiden, B. K., Price, A. D. F., and Dainty, A. R. J. (2003). "Looking beyond processes: human factors in team integration." *19th Annual ARCOM Conference*, Association of Researchers in Construction Management, University of Brighton, 233-242.

Ballesty, S., Mitchell, J., Drogemuller, R., Schevers, H., Linning, C., Singh, G., and Marchant, D. (2007). "Adopting BIM for Facilities Management: Solutions for managing the Sydney Opera House." Cooperative Research Centre (CRC) for Construction Innovation, Brisbane, Australia.

Blaise, M., Dole, S., Latham, G., Malone, K., Faulkner, J., and Lang, J. (2004). "Rethinking Reflective Journals in Teacher Education." In: *International Education Research Conference Melbourne Nov 29 - Dec 2, 2004*, P. L. Jeffery, ed., Australian Association for Research in Education (AARE) Melboure, Australia.

Davis, B. G. (1993). *Tools for Teaching* Jossey-Bass, San Francisco.

Gül, L. F., Gu, N., and Williams, A. (2008). "Virtual worlds as a constructivist learning platform: evaluations of 3D virtual worlds on design teaching and learning " *Journal of Information Technology in construction*, 13, 578-593.

Heesom, D., and Mahdjoubi, L. (2004). "Trends of 4D CAD applications for construction planning." *Construction Management and Economics*, 22, 171-182.

Ingram, H., Teare, R., Scheuing, E., and Armistead, C. (1997). " A system model of effective teamwork." *TQM Magazine*, 9(2), 118-127.

James, R., McInnis, C., and Devlin, M. (2002). "Assessing group work " *Assessing Learning in Australian Universities* Centre for the study of higher education, University of Melbourne, Melbourne http://www.cshe.unimelb.edu.au/assessinglearning/docs/Group.pdf, retrieved 21st June 2010.

Kajewski, S. L., Mohamed, S., Tilley, P., Crawford, J., Chen, S.-E., Lenard, D., Brewer, G., Gameson, R., Kolomy, R., Martins, R., Sher, W., Weippert, A., Caldwell, G., and Haug, M. (2002). "A Brief Synopsis

in the Use of ICT and ICPM in the Construction Industry." CRC for Construction Innovation - Project 2001-008-C, Brisbane.
Kalay, Y. E. (1998). "P3: Computational environment to support design collaboration." *Automation in Construction*, 8(1), 37-48.
Kometa, S. T., Olomolaiye, P. O., and Harris, F. C. (1995). "An evaluation of clients' needs and responsibilities in the construction process." *Engineering, Construction and Architectural Management*, 2(1), 57-76.
Office of Government Commerce (UK). (2005). "Common causes of project failure: OGC Best Practices." <http://www.ogc.gov.uk/documents/cp0015.pdf> (June 20, 2010).
Olatunji, O. A., Sher, W., and Gu, N. (2010a). "Chapter 6: Modelling Outcomes of Collaboration in Building Information Modelling through Gaming Theory Lenses." In: *Handbook on Sustainable Construction: Industrialised, Integrated, Intelligent (I3CON)*, I. Wallis, L. Bilan, M. Smith, and A.-S. Kazi, eds., VTT, Finland, Espoo, 91 - 108.
Olatunji, O. A., Sher, W. D., and Gu, N. (2010b). "Building Information Modeling and Quantity Surveying Practice - whatever you thought, think again." *Emirate Journal of Engineering Research (EJER)*, 15(1), 67-70.
Schmidt, H. G. (1983). "Problem-based learning: rationale and description." *Medical Education*, 17(1), 11-16.
Scott, D. (1980). "Construction Management Training and Teaching in the 1980's." *Australasian Engineering Education Conference*, Institution of Engineers, Australia, Brisbane, Qld, 151-154.
Sher, W. (2004). "Peer Assessment in the Design and Construction of a Reinforced Concrete Lintel." *Centre for Education in the Built Environment (CEBE) Transactions*, 1(*2*), 37 - 55.
Sher, W., Sheratt, S., Williams, A., and Gameson, R. (2009). "Heading into new virtual environments: what skills do design team members need?" *Journal of Information Technology in Construction*, 14, 17-29.
Williams, A. P., Thayaparan, G., and Sher, W. D. (2004). "Working in Groups: A Multiple Perspective Approach to Assessment of Performance." *International Conference on Innovation, Good Practice and Research in Engineering Education*, Wolverhampton, UK
Winch, G., and Deeth, G. (1994). "Managing CAD in architectural practice." *Automation in Construction*, 2(4), 275-280.