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Use of a simulation game in delivering blended lifelong learning in the construction industry – Opportunities and Challenges

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Abstract

Continuing professional development (CPD) and life-long learning are vital to both individual and organisational success. For higher education, the intensive resource requirements requisite in the development of e-learning content and the challenges in accommodating different learning styles, developing an e-learning program can be a resource intensive exercise. A blended learning program has been developed in Ireland in an attempt to address the CPD needs of Irish construction professionals. This initiative attempts to strike a balance between the considerable resources required in the development of an e-learning initiative while addressing staff concerns in integrating technology in the delivery of programs. This pilot explores the issues encountered in integrating a simulation game, called MERIT, on a module as part of this blended learning program. The key finding from this research indicates that simulation games can play a very effective role in the delivery of lifelong learning opportunities aimed at the construction industry. However, management of the integration of a simulation game into a program requires careful planning, establishing key milestone dates and encouraging online collaboration through assigning of marks for effort and use of voice over IP communications.
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1. Introduction

The nature of construction is that of a service industry. Construction companies typically offer skills, not products. The demands on professionals such as engineers, architects, quantity surveys and construction managers are considerable in terms of their time and experience. However, it is widely recognised by leading construction companies that organisations that possess higher skills can make more money, have more satisfied clients and complete more projects on time (Ellis & Thorpe, 2004).

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In Waterford Institute of Technology, a new program has been developed that used a blended learning approach to deliver lifelong learning. A significant consideration in developing this program has been designing the program in a modular format that supports distance learning delivery using technology. One key aim as part of this initiative was to encourage collaborative learning as part of the program. A key component of the program was the integration of a construction based simulation game to facilitate collaborative learning. The aim of introducing simulation into the program was to help participants develop improved analytical and problem solving techniques and to develop a greater understanding of problems and decisions that are faced by a construction organisation.

Rosenberg (2001) characterised employee-learning needs into three key areas: (i) access, (ii) comprehensive approach to access and (iii) information. To address employee needs, organisations also have three requirements: (i) the right information, (ii) an open culture and (iii) an effective technology (Rosenberg, 2001). The need for continuing professional development (CPD) in both the UK and Ireland has been recognised by the construction sector (Egan, 1998, 2002; Forfas, 2003; Latham, 1994; Willott, Dowson, & Irving, 2004). A key driver in addressing the issues identified in many of these studies has been the recognition that learning and training are key elements in delivering these construction projects. This results in greater certainty about the time of completion and a greater likelihood that projects will be completed within budget. However, the intensity of workload that exists within the construction industry means that frequently there is insufficient time available for effective learning to take place to meet deficiencies within the industry (Construction Industry Council, 2004).

The phenomenal growth of the Irish construction industry over the past decade, coupled with the increasing complexity and scale of projects has fuelled the demand for project managers with specific knowledge and skills. Wearne (2004) in a survey of chartered engineers identified two areas of managerial skills and expertise requirements, in leadership and in the management of projects. A Forfas (2003) identified project management as one of the four major areas of emerging skill needs in the construction industry. Fas (2006) in a study titled "Study of Project Management Skills in the Irish Construction Industry" made a number of suggestions for formal education and training, including the use of role play and practical experience, removal of the "class room" approach and that material should be relevant and practical.

Construction project managers are charged with the responsibility to deliver projects to the required quality within agreed budget and schedules. Facilitating lifelong learning and CPD opportunities to improve project management skills is a challenge that technology and the use of simulation games can play key roles.

2. Continuing professional development

CPD and lifelong learning are vital to individual and organisational success (Browell, 2000). Typically acceptable CPD learning includes 35 h of recognised activity or 100 points (equivalent to credits awarded) of CPD learning with a recommendation that 50% of the professional's CPD be structured i.e. classroom or lecture setting (source: various professional institutions).

Typically formal CPD can take any of the following formats:

- Training courses, both internal and external.
- Post-graduate academic studies such as diplomas and masters.
- Attending appropriate technical lectures, as typically organised by professional institutions.
- Significant involvement in the work of a learned institution, e.g. presentation of a technical paper or the preparation of a report.
- Participation in technical conferences or study visits.
- Special exam leave.

The traditional approaches to the delivery of CPD are not always flexible enough to address learners' needs. While there is recognition that the Internet can have a role to play in meeting CPD needs of construction professionals, it can only happen if a number of conditions exist. The Internet provides new opportunities and promises potential for distance education worldwide (Shen & Scott, 2004).

3. Internet and learning

Chan and Welebir (2003) highlighted that e-learning creates new opportunities, but also introduces new obstacles for the traditional higher-level institution. Bruce (2003) recognises that more and more people are using the Internet to send e-mail, instant messaging, browsing, finding entertainment information and reading news – "...today's students think of the Internet the way their parents and their grandparents – and even their older siblings – viewed electricity: ubiquitous and only noticeable when not available" page 24. While there has been much research into the technologies available, less attention has been dedicated to integrating technology to improve the learning process (Derntl & Motscing-Pitrik, 2005).

Gibson, Tesone, and Blackwell (2001) identify 10 lessons to making the distance learning programs more valuable. These are:

  (i) changing the thinking from a teacher centred to a learner-centred environment,
 (ii) learning the support technology,
(iii) making the website user-friendly, interactive, fun and interesting,
 (iv) personalising courses and building a sense of community,
  (v) utilising many methods of communication,
 (vi) being creative with on-line testing,
(vii) breaking work down into smaller elements and establishing absolute deadlines,
(viii) providing timely feedback to students,
 (ix) making participation count,
  (x) ensuring to establish who owns the course, the instructor or the school.

Often it is in an eagerness to embrace technology that an understanding of the fundamentals of learning and how it occurs is overlooked (Hamid, 2002). Successful e-learning participants are highly motivated and self-directed, intellectually more mature, self-disciplined, older, serious and interested in coursework from which they will materially benefit (Schweizer, 2004). With the growing acceptance of e-learning technologies and the increasing need of access to distance learning opportunities, administrators of higher-level institutes face; (i) technological, (ii) organisational, (iii) pedagogical and (iv) cultural challenges in helping to integrate these changes (Howell, Saba, Lindsay, & Williams, 2004). The prevalence of online distance education courses requires management, technical support and teaching staff to face new challenges and make new decisions. For many institutions the new technologies that are available, represent a largely additional expense that is difficult to quantify (Twigg, 2003).

4. Costs in deploying e-learning

The range of estimates for development of e-learning content varies, from small financial resources required to huge financial commitment (Mayer, 2003). If one takes a conservative costing of €50 per hour for development and delivery of content, Fig. 1 highlights the range of costs that may be incurred in the development of online resources.

Fig. 1 serves to highlight some of the challenges that educational institutions face when attempting to move from traditional delivery of programs to a totally online program including virtual simulations. Cost conscious managers in higher-level institutes can enhance the utilisation of resources by using a variety of distance learning technologies ranging from low cost print to more expensive leading edge technology (Banas & Emory, 1998). Alexander (2001) states that while much of the focus in e-learning has been around the level of technological delivery strategies, other issues such as staffs' conception of learning and understanding of how students learn, teaching strategies appropriate for use with e-learning and the need staff development opportunities need to the factored into any developments. Using a blended learning approach may overcome many of the staff concerns with integrating technology as part of the delivery of learning and also help "mitigate" the considerable costs that may be incurred in going to a totally online delivery model.

Blended learning may bring about major changes in the way educational material is designed, developed and delivered to people who want to access learning but have other constraints that affect the process of
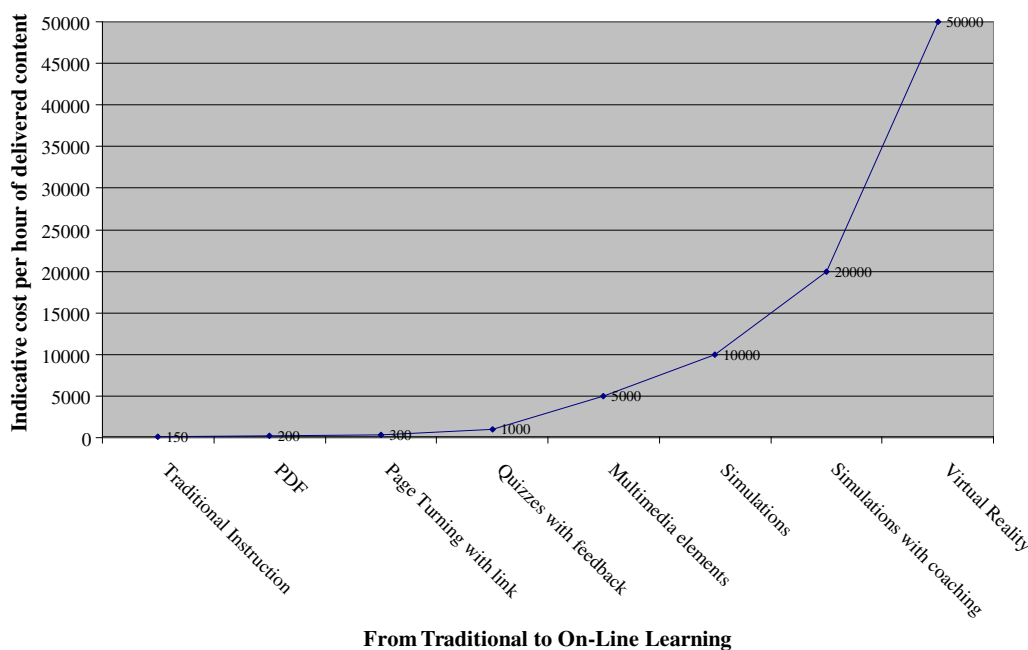
Fig. 1. Indicative cost to deliver one hour of instruction using a range of methodologies. Source: Wall et al., 2006.

learning (Pailing, 2002). Depending on the nature of the material to be developed cost influences decisions on what the nature of the blended learning should take (Wall, Smit, Betts, & Ahmed, 2005).

It must be recognised that learning is not a simple act. The Chinese proverb, attributed to Confucius (450 BC), summarises the importance of understanding the pedagogical processes that take place when learning occurs:

"Tell me, and I will forget, show me, and I may remember, involve me, and I will understand."

One such method introducing the "tell", "show" and "involve" is the use of simulation and gaming to enable these managers to experience the range of typical decisions that senior managers face daily in construction companies. The MERIT simulation game aims to encompass the "tell", "show" and "involve" that are key to enhancing the learning experience.

5. Simulation and games in learning

Simulation can be defined as "an imitation of the reality of some system, process, or environment" (Forssen-Nyberg & Haramaki, 1998, page 170). Simulations and games fall into a learning category that is sometimes called discovery or experiential learning (Dolezalek, 2003). Simulations mimic processes that occur in the real world. Computer simulations historically have been used in specific scientific disciplines such as engineering, bio-sciences and for high-risk occupational training such as military, aviation and medicine (Jackson, 2004). Kryukov and Kryukova (1986) define the characteristics of simulation games as having three elements:

- Any simulation game always reflects reality.
- A simulation game is embodied in a form of social communication.
- The evaluation of reality together with self-evaluation and reflection.

One of the principle reasons for the inability of traditional methods to facilitate the development of flexible and useful knowledge and skills is the lack of contextualizing or anchoring of the content being learned (Lainema & Nurmi, 2006). The use of simulation games provides an ideal alternative method of testing concepts in

Table 1
Attributes of games as part of learning

Aspect	Attribute
Social	Games are often social environments, sometimes involving large distributed communities.
Research	When a new player enters a game or simulation, he or she must immediately recall prior learning, decide what new information is needed and apply it to the new situation.
Problem solving	Knowing what information or techniques to apply in situations enables greater success, specifically problem solving. This often involves collective action through communities of practice.
Transfer	Simulations and games require transfer of learning from other life situations. Being able to see the connection and transfer of existing learning to a unique situation is part of game playing.
Experiential	Games and simulations are inherently experiential. Those who play games and simulations engage multiple senses. For each action, there is a reaction, feedback is swift, hypotheses are tested and users learn from the results.

Source: Oblinger, 2006.

an environment that resembles realistic work situations (Al-Jibouri & Mawdesley, 2001). Simulations and games have many attributes detailed in Table 1 that are associated with how people learn (Oblinger, 2006).

De Freitas and Oliver (2006) state that when faced with introducing simulation-based learning into learning settings, educators are faced with several questions:

- Which game or simulation to select for the specific learning context?
- Which pedagogic approaches to use to support learning outcomes and activities?
- What is the validity of using the chosen game or simulation?

Management games have a long history in education and training in construction and have the advantage that they enable participants to be put into complex realistic situations without incurring the financial penalties which would accrue if real projects were used (Al-Jibouri & Mawdesley, 2001).

Egenfeldt-Nielsen (2004) identified the barriers to introducing games and simulations into educational settings as time scheduling, physical setting, group expectations, experience with group work, instructor background, genre knowledge, technical problems, instructor preparation, perception of games, group size and proximity and concluded that these factors add up to a considerable workload on instructors that wish to engage with computer games and demands that the instructor possess a variety of skills. Van Eck (2006) when discussing digital game-based learning (DGBL) suggested that what is now required is research explaining why DGBL is engaging and effective and practical guidance for how (when, with whom and under what conditions) games can be integrated into the learning process to maximise their learning potential.

The following sections outline an initiative in Waterford Institute of Technology, which embraces these challenges by introducing a simulation game in a unique context in the Irish construction industry. Through the use of both classroom and distance learning modes as part of the blended learning approach to delivering lifelong learning in the construction industry in Waterford Institute of Technology, it was anticipated that a high level of commitment would be maintained and the sense of isolation that participants can often experience would be removed. This was the approach applied in the formulation and delivery of a new blended learning CPD program. This new program is a Master of Science in Construction Project Management.

6. Waterford Institute of Technology

This post-graduate program has been designed to facilitate professionals in the Irish construction industry (including engineers, construction managers, quantity surveyors and architects) who wish to enhance their education and gain an additional qualification. The structure of the new program is unique to construction related post-graduate education in Ireland in that it involves a mixture of 'distance learning' and 'traditional learning' techniques in the completion of the various subject modules.
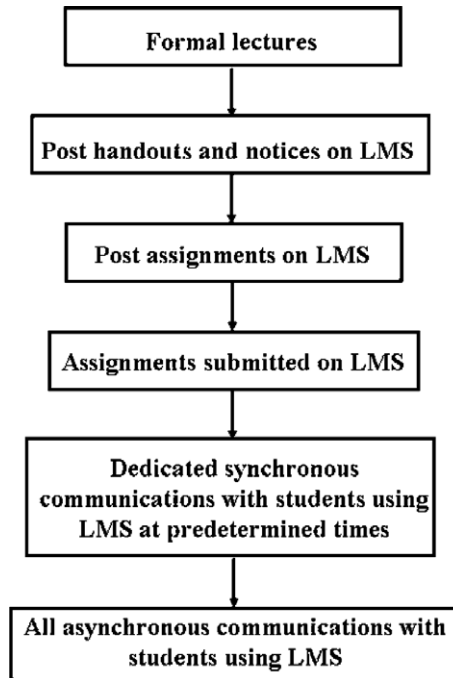
Fig. 2. Schematic of operational delivery of a module.

In order to ensure that students were meeting deadlines and remained motivated, computer-mediated communication was used by lecturers to post notes, discussion items and online material on the learning management system (LMS). Fig. 2 illustrates schematically the typical approach used in the delivery of each of the modules.

When designing the program, it was recognised early in the development, that to engage the students thought the use of a blended learning approach, that the use of simulation games could play a pivotal role. While there a number of simulation games available for use as part of construction learning, after carrying out a review of some of the alternatives available, a simulation game developed by Loughborough, MERIT was selected for integration as part of the program. This is a well established game that has been used since the early 1990s as part of learning programs in the construction industry.

7. Description of MERIT

MERIT is a computer simulation game developed by Loughborough University in the UK and is a pseudonym for Management, Enterprise, Risk, Innovation and Teamwork. It is a computer simulation game that enables participants, grouped into a team, the opportunity to experience managing their own fictional construction company. Participant can interact with the game in a safe, but realistic and challenging environment. Typically, this takes place either as part of the final year module of an undergraduate program or as part of an intensive 2/3 day period. The unique approach used on this program was to deploy it over a six month period while people continued to work in industry and collaborated remotely as part of engaging and interaction with the game.

The MERIT simulation introduces many of the key concepts and problems that are faced in the construction industry. These include (i) the importance of a construction company formulating a long-term strategy, (ii) the need for effective teamwork and communication skills, (iii) ways of measuring company performance, (iv) the importance of marketing, and the need for accuracy in estimating and (v) managing risk in construction.

Particularly in construction, it is important to include uncertainty in projects, to mimic real construction projects (Al-Jibouri & Mawdesley, 2001). As part of the MERIT game participants are exposed to aspects

of construction management with which they are possibly either unfamiliar or unpractised, and by allowing them to investigate the interlocking nature of the decisions they make regarding the different areas of company management, a more holistic perspective of the whole construction process is engendered.

MERIT allows participants to take the role of company managers bidding for work in a competitive environment and carrying out the work that they win in order to make the company successful (Al-Jibouri & Mawdesley, 2001). The simulation game allows participants to develop their strategic thinking by making decisions to improve key performance indicators for the company (Wilkinson, 2005).

Some of the key decisions that have to be made each period include (i) deciding which market sectors to target for future work, (ii) pricing the jobs for which the company has pre-qualified and (iii) progressing each contract awarded by managing the labour force and site staff, and allocating a project manager to the site. The learning aspects of MERIT are enhanced in a number of ways:

- An interactive tutorial, in the form of a slideshow, guides the user through the simulation.
- A detailed set of company reports are available in different formats.
- Feedback is given each round about company performance in each business area from an external consultant (i.e. game controller).

This feedback is vital as it allow the team to review their performance, make interventions and changes that may improve the performance of the fictional company going forward.

8. Operation of MERIT simulation game

Participants are grouped into teams, with each team operating as a board of directors, making decisions that affect the various functions of the business, such as marketing, estimating, bidding, finance, personnel and construction. Fig. 3 is an outline of the typical roles that may be assumed in the game.

For each of the roles that must be assumed as part of the simulation game, there are a series of activities that must be undertaken. These are outlined in Table 2.

Each round, known as a period, represents one quarter, or three trading months. Starting from an historical position of one year's trading, a company must be managed through two phases (i) ''The Early Years'' and (ii) ''The Final Years'' which is optional.
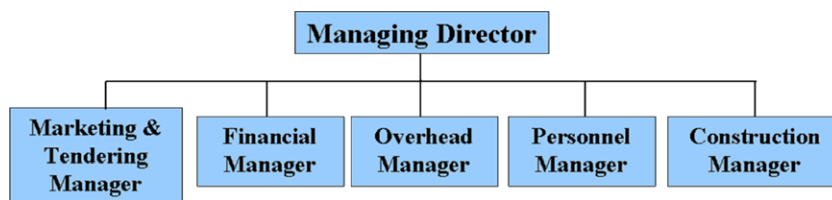

Fig. 3. Typical roles in MERIT simulation game.

Table 2
Typical activities for the various roles in the game

Role	Typical activities
Marketing and tendering	Seeking out future work costing and bidding for jobs
Financial Manager	Managing assets, liabilities and share price
Overhead Manager	Responsibility for staffing key overhead departments, (i) marketing, (ii) estimating, (iii) head office and (iv) measurement
Personnel Manager	Allocating project managers for ongoing jobs
Construction Manager	Progressing jobs by allocating labour to site and ensuring there is enough administration support

The dynamics of this stage of the competition enable the teams to appreciate the impact of each decision they make. During the final years the teams compete against the computer-generated company and each other for both jobs and staff, ensuring an even more highly competitive environment.

To be able to take part in a MERIT Competition, at least one member of the team was required to have:

- A computer running on the Windows operating system (95 or above).
- A Pentium processor, or equivalent.
- Access to a printer.
- An e-mail address for sending and receiving information.
- Access to the Web to view the information about a game.

9. Implementation of the MERIT game on a blended learning CPD program

The program in WIT was delivered using a blended approach. The participants attended campus on six occasions, typically for two and a half days, between the middle of September 2005 and the beginning of April 2006. Participants commenced using the MERIT simulation game in November 2005 after receiving a presentation on the background to the game. There were eight participants on the program divided into four teams. Ideally to make it most effective, having teams of four is more valuable in terms of peer and collaborative learning taking place. However, to generate a sense of competition the decision was made to run the game with four smaller teams. In practice as this was a blended learning program, all participants had the requisite technology available both at work and at home.

The MERIT software is a single-user version for loading on individual PCs. The game controller e-mails the company database for a period to each of the teams. Having made their decisions for the period, the team must email their database file back to the game controller in Loughborough.

Overall company performance is measured by key performance indicators and company performance statistics that are available at all times. The simulation is designed to demonstrate the interdependence of these decisions, and the interlocking nature of the variables that determine the success or failure of the company.

As well as their own decisions, a number of other factors affect a company's performance. These are referred to as company and financial information, and define the environment in which the company is operating. Fig. 4 represents how the financial information is inputted into the system.

The decisions made each period need to be based upon a sound company strategy which reflects the objectives of the company and how the objectives are to be achieved. In order to decide upon the objectives, and what can be realistically achieved, there needs to be a detailed analysis of (i) the environment in which the company is operating, (ii) the strengths and weaknesses of the business as it stands and (iii) the likely competition in the future.

Fig. 4. Imputing financial information.

Fig. 5. Performance position report.

To overcome the sense of isolation that people often experience on programs that encompass a significant distance learning element, each of the participants were inducted into using voice over Internet protocol (IP) technology (Skype, a freeware solution) to encourage computer-mediated communication. Participants found this very effective in communicating on the various modules between face-to-face sessions.

A further benefit of using voice over IP was that it enabled teams to meet online to discuss strategy as part of the MERIT game. Typically, participants on a team both logged on at a pre-arranged time, they then discussed and agreed a strategy for moving the company forward, they viewed the implications of their decisions on their own PC, and then the nominated person submitted their agreed decision to the game controller.

Each team begins the game with 1000 points and the objective is to gain build on these 1000 points as much as possible. Fig. 5 highlights how this looks on the game website.

It is primarily a serious training vehicle, enabling participants to gain an understanding of the complexities of running a modern construction company, and the inter-relationship between the various functions of the business. For participants to manage their virtual company as productively as possible, they need to spend time learning how to use the simulation.

10. Evaluation of MERIT simulation game

In attempting to integrate the game, it was initially anticipated that the phases would be spread out over the duration of the program. It was expected that the participants would talk about the strategy for their team going forward at each of the occasions that the met face-to-face. However, due to work commitments and the demanding rigours of the program, this did not prove to be the case. Dates and deadlines for submission of the individual company strategies were missed.

As part of the evaluation process on the program, the participants were asked to evaluate the integration of the game into the program under a number of headings. The major issues considered were:

- Did the game assist in developing a greater understanding of the problems and decisions that are involved in running a modern construction company?
- Whether the game's purported practical and competitive nature enhanced the learning environment?
- Did the MERIT simulation game improve team-working, communication and IT skills?
- Did the game facilitate in the development of analytical and problem-solving techniques?

The main benefits of using the MERIT simulation are:

- It develops a greater understanding of the problems and decisions that are involved in running a modern construction company.
- Its practical and competitive nature enhances the learning environment.
- It improves team-working, communication and IT skills.
- It develops analytical and problem-solving techniques.
- It enables performance to be benchmarked against other competing teams.

Participants found that the game did contribute to a greater understanding of the problems and decisions to be made in the management of a construction company. All the participants found that the feedback from the game controller in Loughborough was very prompt and beneficial in keeping everyone engaged with the game. Participants in commenting on the game found that it was "extremely enlightening and enjoyable", "an effective tool which enables participants to gain an understanding of the complexities of running a modern construction company", and "increased both the level of teamwork and communication skills".

However, the integrating of a simulation game into a program such as this still presents challenges. Suggested improvements that could be made in integrating the MERIT game into the program in the future included:

1. Ensure the competitive nature is maintained by assigning marks for completion of stages at the appropriate time to ensure that the competitive nature is maintained. This will foster competition among groups as the stages progress. This should be facilitated by establishing, possibly two milestone dates.
2. To overcome possible ICT difficulties in terms of software and hardware, the purchase of laptops for participants at the commencement of the program with all necessary software preloaded on the PC should be considered. This computer-mediated communication may include voice over IP collaboration software (i.e. such as Skype) as well as the simulation game. When an individual signs up for a traditional distance learning program (e.g. Open University) all the material required is mailed to them. As educators in more traditional third level education institutions, embracing the approach of distance learning providers and providing laptops at the commencement of programs should be investigated further.
3. As part of the program, there should be time set aside to demonstrate inputting of information into the simulation game when participants are in the trailing stage, when the students meet for the face-to-face element of the program. This should be done early in the program delivery.
4. Subsequent to this, at one of the later sessions of the program, a period should be set aside for all the groups to input a stage report to further foster competition. This could be integrated with presentations made by the groups on the strategy being pursued, and lessons learned to date.
5. Some participants felt that there was no aspect of management of Health and Safety incorporated into the game. Given the increasing importance of this aspect of construction work, any means of building this into the program should be considered.

11. Conclusion

There is a range of options available to construction professionals who wish to undertake CPD opportunities. However, for busy professionals who wish to access CPD, traditional classroom instruction is often not flexible enough. Blended learning is one approach that may be exercised to bridge the gap between academia and professionals in the construction industry. Simulation games, such as the MERIT game can be a very effective enhancement to the learning experience, if incorporated effectively into the delivery of the program. Through the allocation of marks to encourage participation and maintain motivation, it may be a very effective tool to enhance the learning experience. Thought should be given by academics to ensure that the game is structured appropriately, by establishing milestone dates for the completion of the various phases. Assigning marks for elements should encourage this to happen. The use of voice over IP technologies is a very effective way to encourage collaborative learning and enhanced decision making by allowing team members to view decisions in real time and discuss implications of decisions. As the game is already well established it is a cost effective way of enhancing the learning process when proper planning and structures are established integrating it into a formal program.

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