The use of ACT-UK virtual reality simulation centre to enhance the learning experience of undergraduate building students

The use of ACT-UK Virtual Reality Simulation Centre to enhance the learning experience of undergraduate building students

Stephen Austin and Robby Soetanto

Abstract

The National Centre for Advanced Construction Technology (ACT-UK), based at Coventry University, is a newly established construction management simulation centre. The aim of this research is to investigate the possible role of ACT-UK in the undergraduate Building degree curriculum at Coventry University. Case study methods are adopted and include questionnaire surveys and interviews of construction employers, students and academics to develop a proposal for the possible use of the new simulation centre. The analysis indicates a high degree of enthusiasm for the use of the new simulation centre, but also raises issues regarding its cost and the ease with which it can be embedded into the current curriculum. Following on from the analysis, an outline of a programme that meets the needs of all parties is presented. The case study offers a lesson for the adoption of an innovative new learning approach to enhance the student learning experience within a higher education context.

Introduction

ACT-UK is a national centre of virtual reality simulation funded by Advantage West Midlands (the regional development agency) and located at Coventry University Technology Park. In business terms, ACT-UK is a separate entity from the University. ACT-UK aims to use the latest technology for construction management training. The centre aims to deliver situations with all the pressures, issues and interruptions that are experienced on a real building site and incorporates a philosophy that the trainees will first need to identify and define problems and develop a thorough understanding of their nature in order to formulate a response. The response is then analysed and presented. As part of its training process, the centre uses a form of semi-immersive virtual reality simulation (VRS) where the users feel as if they are in a situation and interact with actors as necessary (Horne and Hamza, 2006). This is unique to the UK and is based on the VR technology being used at the Building Management Simulation Centre (BMSC) in Leeuwarden in the Netherlands (Vries et al., 2004). It offers learners a simulated learning environment based on the complexities of operating within a construction site. Within their “site huts”, learners will complete

specific construction related tasks whilst actors play a variety of roles that a construction manager may encounter during a typical day (Stewart, 2007). As suggested by Macdonald and Savin-Baden (2004) in the context of problem-based learning, the students are not expected to produce "right" answers, but to engage with the complex situation presented to them. At the end of the training session, the learner will be able to review the process and discuss the consequences of the decisions that they took - therefore the actions that the learner undertakes can be shown in direct relation to the building construction. This approach tends to be stronger than the traditional approach of verbal or written descriptions of the possible consequences.

The new simulation centre aims to offer training which complements existing education and training programmes and therefore its use could be considered in relation to the existing undergraduate Building degree programme at Coventry University. However, the new centre will **not** be offering full education but will focus on problems that require 'soft' skills that can be developed through experience (Taylor, 2008), thus the possible uses of the centre for students are:

1. To be embedded within one or a number of existing modules that form the Building degrees
2. Offered as a new module within the Building degree framework
3. Offered outside the framework of the existing Building degrees.

To ascertain the collaboration possible, it is necessary to establish the 'soft' skills that the new centre aims to deliver. The simulation centre has undertaken a full review of the Chartered Institute of Builders (CIOB) educational framework (CIOB, 2009). In addition, a development team from the centre, in conjunction with members of the construction industry, has identified competency and skills categories which were deemed the most important for a UK site manager (Stothers, 2007), these being:

- leadership
- understanding client needs and contract requirements
- planning and organisation
- monitoring and controlling performance
- problem solving and risk management
- team and people management
- communication

Therefore, the key question to be investigated is the possible use of the simulation centre in relation to the Building degree curricula at Coventry University. To explore possible answers a case study approach has been adopted. The case study combines different data collection methods that provide the results and are used to develop the proposal.

Research methods

Case study research aims for an in-depth understanding of a phenomenon that is inseparable from its context (Yin, 2003). Case study employs different combinations of data collection methods for bringing together different evidence (both quantitative and qualitative) that must be woven together to form a coherent argument that should be interpreted within a particular context (Proverbs and Gameson, 2008). Hence the goal of a case study, as presented here, is not statistical generalisation (Yin, 2003), but to explore possible answers to the research question by interrogating authentic data obtained from the actors of the phenomenon. Data were obtained from structured questionnaires and an interview/meeting. The respondents were academic staff within the Department of Built Environment at Coventry University, undergraduate Building students in the department and employers in the construction industry (considered the key stakeholders of the learning process). Staff and employers had previously received presentations about ACT-UK, whilst the student questionnaire included an explanation of how the simulation centre worked.

Structured questionnaires

The first method of data collection took the form of three anonymous structured questionnaires. The first questionnaire, for the academic staff of the Department of Built Environment, contained the following questions that required a simple yes/no response. After each question, a second question was asked which required the respondents to give a more detailed answer regarding the views expressed previously:

1. Should the use of the ACT-UK simulation centre be incorporated into the curriculum of the undergraduate Building degrees at Coventry University?
2. Should ACT-UK be used in all of the building degrees at Coventry University or just within the Construction Management degree?
3. Do you think the use of ACT-UK in the curriculum should be embedded in the current modules provided or as new separate modules?
4. If ACT-UK is to be embedded into the current curriculum for all the building degrees/Construction Management degree, using the list of modules that form the framework (which was provided in the questionnaire), please state which modules you think it should be contained within.

The second questionnaire, to the final year undergraduate Building degree students, consisted of questions taken from the first questionnaire, but without asking the respondents to elaborate on their answers. The final questionnaire, to the employers within the construction industry, asked

only questions 1 to 3, along with their viewpoint. As such, the questionnaires generated both quantitative and qualitative data (The Open University, 2007).

Interview/meeting

Having undertaken the questionnaires, the second data collection comprised an interview. Where the questionnaires targeted *all* staff involved with the delivery of the undergraduate Building degrees at Coventry, the interview was carried out with the Head of the Built Environment Department (as the person responsible for the possible financial implications of using the ACT-UK simulation centre) and a member of staff from the new simulation centre responsible for developing new courses. The Head of Department had not previously completed a staff questionnaire and the interview took a semi-structured form based on the responses given by other staff members, the factors that could affect the department from the use of the simulation centre and, in relation to these factors, how the simulation centre could benefit all undergraduate Building degree students.

Results

Just as the data collected for the case study used two approaches, so too did the analysis of the data in relation to the main aim of the study. Data obtained from the first part of the questionnaires were placed into pre-defined numerical categories and presented pictorially. Responses obtained from the second part of the questionnaires were qualitative in nature, and categories were allowed to emerge during analysis rather than being predetermined before the data was collected. These categories then formed the schedule for the interview. All of the qualitative data obtained from the questionnaire and from the interview was used to help in the interpretation of the quantitative data.

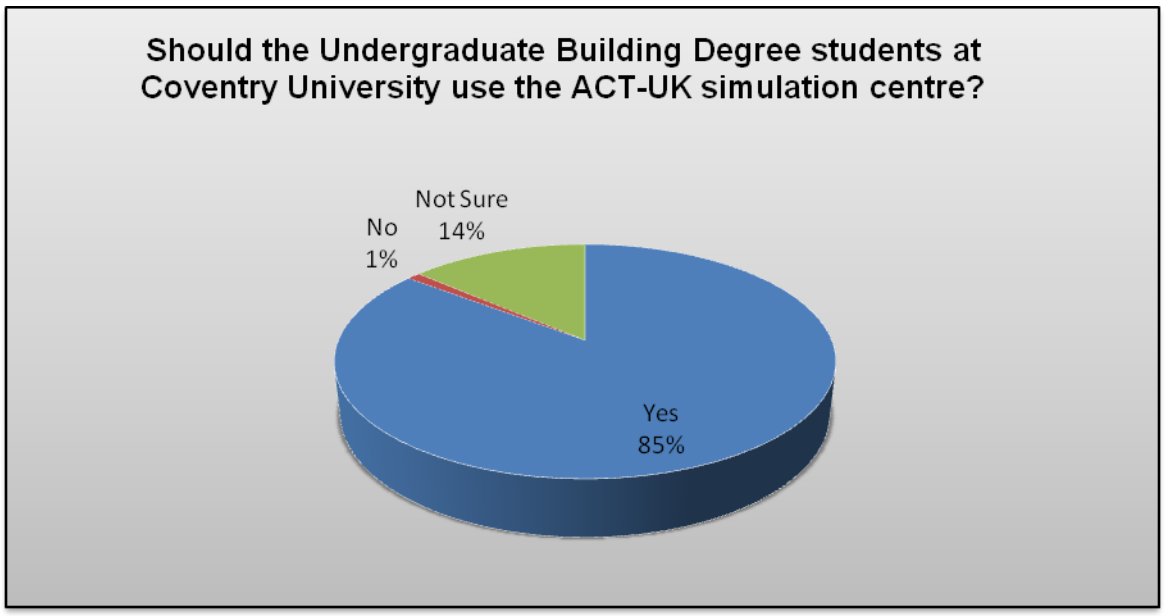
There was a varying response from each of the three groups. Eight responses were received from staff (a 72% response rate) and thirty-nine from students (a 97% response rate). Only four responses to 14 employer questionnaires were received, making a response rate of just below 29%. This low return rate is not unexpected as the questionnaire was issued via the external post; a factor which Bell (1999) says causes a problem with “non-response”. The low response rate also raises issues regarding bias: were the members of the construction industry in favour of the simulation centre more likely to respond than those with no specific opinion? However, as the employer questionnaire was undertaken anonymously, there was no way of chasing non-respondents and analysis had to be based on the results received. To allow comparability of the responses, the quantitative results from the questionnaires have been compiled as percentages

rather than a tally system. In addition, results have been normalised to take into account the disparity in the number of responses between the three groups (percentages from the three groups of respondents were averaged to give the overall results).

Results from question 1

The combined quantitative responses from the three groups are presented in Figure 1.

Figure 1. Comparison of data from question 1



To the question ‘Should the undergraduate Building degree students at Coventry University use the ACT-UK simulation centre?’ responses from both employers and students were extremely positive, with 100% and 95% agreement respectively. The positive response from staff was less, when compared to the other two groups, at 62%. To understand the difference it is necessary to look at the qualitative responses.

The overriding response to the incorporation of the simulation centre into the curriculum from the employer questionnaire was that it offered hands-on experience. This response was uniform amongst all of the employer questionnaire responses. However, the staff saw the use of the simulation centre as an opportunity ‘to get an almost real life taste of what managing a project is about’, but voiced concerns about the cost of using it. This was commented upon by a number of respondents, stating that there was a need to look at the financial commitment involved. Another concern, raised by a couple of respondents, was the ability to fit the simulation centre training into the current module structure and mapping it onto existing learning outcomes. This concern could be mitigated by question 3 which looks at the placing of the simulation centre within the curriculum as either embedded or as a new module, and is discussed in a later section.

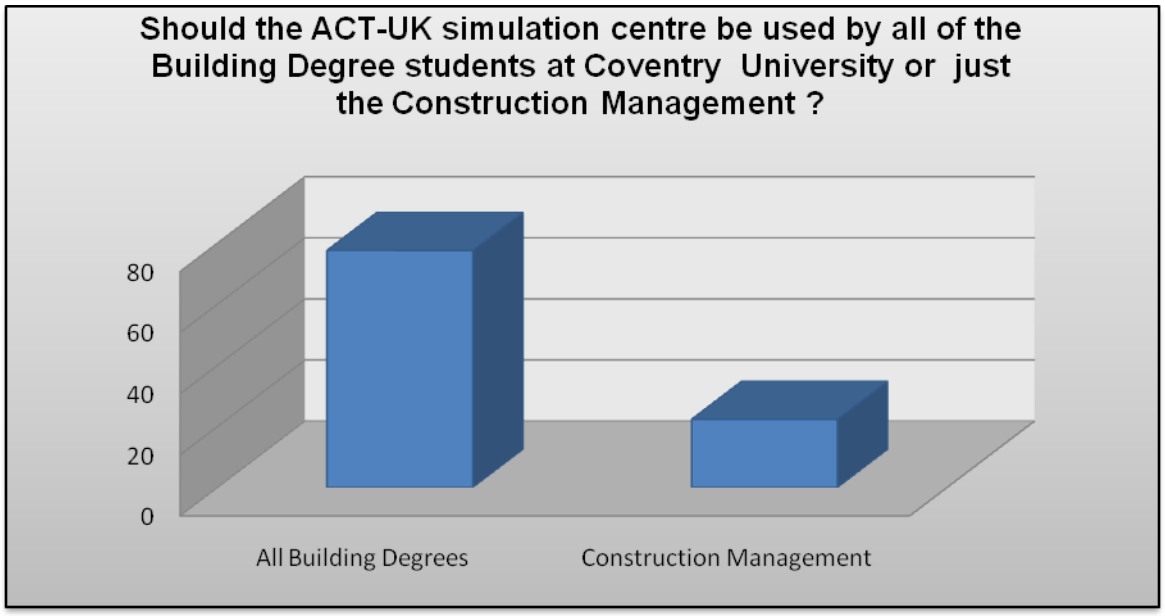
Other concerns raised were about the amount of curriculum time that would be taken up if the simulation centre were used and the amount of prior knowledge that the students would need to have if the use of the centre was to be effective.

The results show a positive endorsement for the use of the simulation centre. The next focus of the case study was to investigate whether the respondents thought it should be offered to all undergraduate Building degree students.

Results from question 2

Respondents who did **not** think that the simulation should be incorporated into the curriculum were not included within this question. The combined quantitative responses from the three groups are presented in Figure 2.

Figure 2. Comparison of data from question 2



All of the employers thought that the simulation centre should be included in all of the undergraduate Building degrees at Coventry University. This is higher than responses from the staff and students, 62% and 73% respectively.

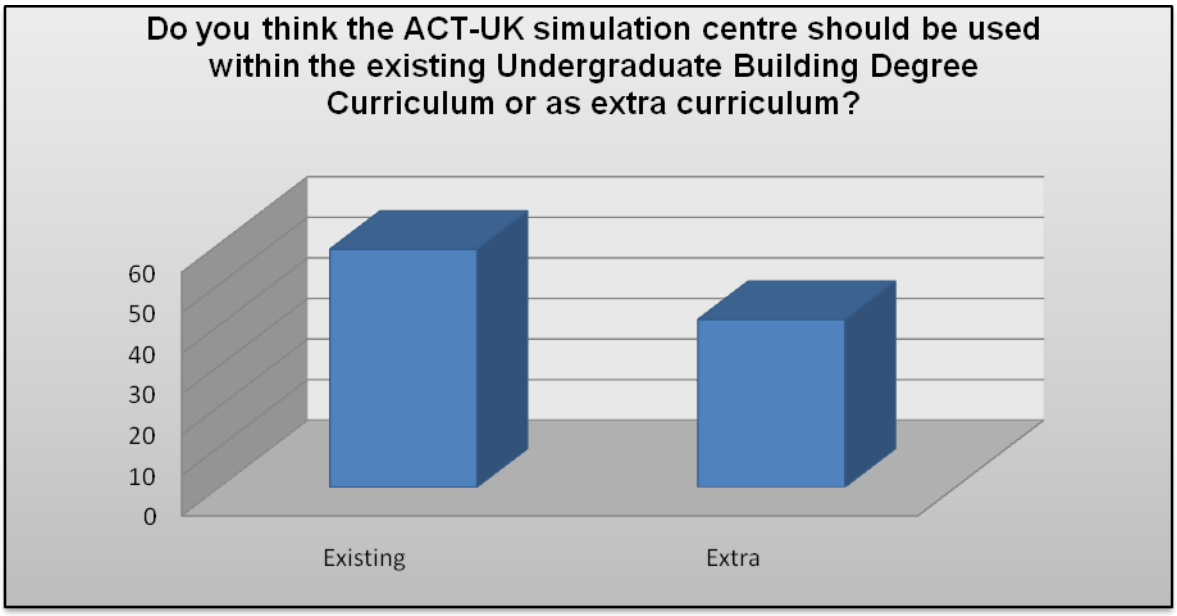
The qualitative response from the employers shows that a key reason for Building degrees students to use the simulation centre is so that each student, within their respective construction profession, can interact with others and therefore achieve a better understanding of each others' roles: 'it is not just contractors that need to understand construction on site, but designers, engineers, surveyors/cost consultants etc.' This, to a lesser extent, is backed up by the staff responses: 'a test of management skills and working under pressure, something that all building professionals will experience.'

The case study therefore tends to indicate that all undergraduate Building students would benefit from training in the centre. Therefore, the next focus was to investigate whether the centre should be offered within the existing undergraduate Building degree curriculum or as an extracurricular activity.

Results from question 3

The combined quantitative responses from the three groups are presented in Figure 3.

Figure 3. Comparison of data from question 3



What is interesting about the data from question 3 is that there is a range of responses to the question from the three different groups questioned. The range was from 67% of employers saying it should be used with the existing curriculum down to 50% of staff. The student response was in the middle of the range, at 58%. To understand the reason for the range, it is again necessary to look at the qualitative responses to the question. The qualitative data tends to suggest that more employers thought the simulation centre should be used within the existing curriculum for the same reasons given in their response to question 2. Here, 100% of all employers thought that the simulation centre should be used in the entire undergraduate building degrees. Their responses to question 3 tended to focus on the fact that, as they thought it was important for all disciplines to use the simulation centre, it should be used within a range of modules affecting all undergraduate Building degrees.

The real split in opinion, however, comes from the staff, with the responses being divided equally. Looking at the qualitative data, there seem to be a couple of areas about which staff have concerns. The first is the cost of the simulation centre, as highlighted by the responses to question

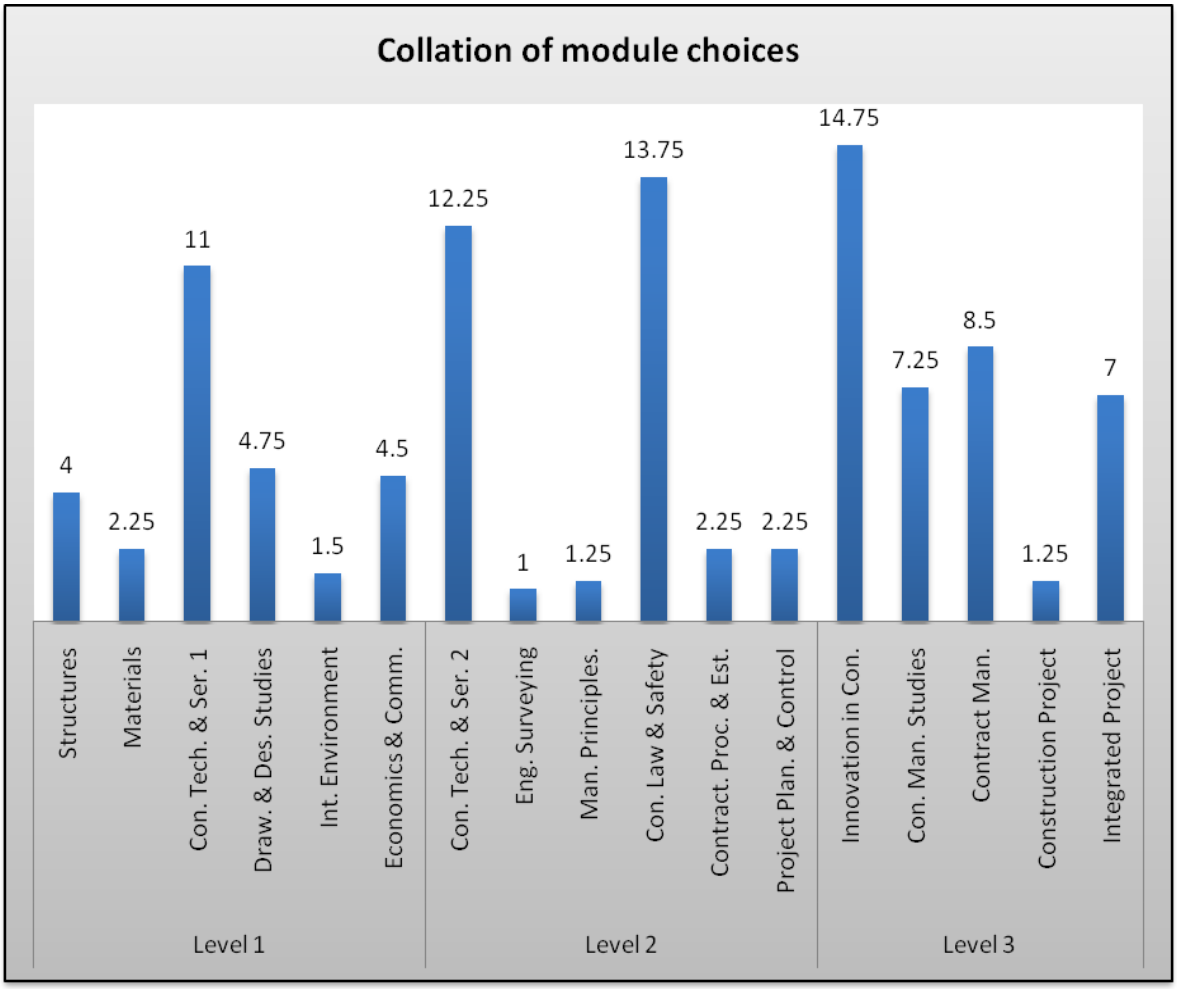
1, but by far the larger concern was the impact on time that might occur if the simulation centre was used within the existing degree curriculum: ‘For most students the time would not justify a complete or half module.’ This is further evidenced by the staff opinion that if the simulation centre were used within the existing degree curriculum then something else would need to be removed to make way for it. This raises an important issue. It could be argued that nothing would need to be replaced as the simulation centre could be used to replace the way existing elements of the curriculum are currently delivered. However, the simulation centre focuses very much on the “soft” skills required within the construction industry. Currently, some form of these skills is offered within the existing course as “transferable” skills, but they are embedded across the different modules within the various courses and, as such, are not separately assessed. This makes the use of the simulation centre as a replacement for existing teaching more difficult.

As the case study data narrowly showed that the use of the simulation centre should be within the existing curriculum, the next focus was to investigate which modules were thought appropriate.

Results from question 4

The module choices made by the staff and students from question four have been combined to produce the information in Figure 4.

Figure 4. Collation of module choices from question 4 (%)



The data confirms possible module choices from the undergraduate Building degree programme:

- Level 1 – Construction Technology and Services
- Level 2 – Construction Law and Safety
- Level 3 – Innovation in Construction.

The level 1 module chosen is aimed at delivering the technical ”hard” skill requirements of construction education, something upon which the simulation centre is not focused. With regard to level 2, the safety aspect of the Construction Law and Safety module would be something that the simulation centre could focus upon. The level 3 choice possibly relates to the fact that the new simulation centre is deemed to be a new and innovative way of delivering teaching and thus ties in with the module name. The focus of the module looks at new innovation within construction and, as such, could involve the use of the simulation centre in some form, if only as a visit. However, taking into account the low suitability of the modules at all levels, the question has to be raised as to whether the current curriculum is fully compatible with use of the new simulation centre.

Having reviewed the quantitative and qualitative data, the following summary can be made:

- the use of the simulation centre is deemed applicable to all undergraduate Building degree students
- the use of the simulation centre within all the undergraduate Building degree courses needs to be balanced against certain factors:
    - costs
    - appropriate module choices from the current curriculum suitable for the simulation centre
    - ability to fit into the current curriculum due to time and existing content

Having analysed the data from the initial focus of the research, a question arose that needed to be investigated through the interview/meeting:
What impact will:

a. cost;
b. curriculum time;
c. appropriate module choice;

have on the use of the simulation centre by the undergraduate Building degree students at Coventry University?

Results from meeting

Arising from analysis of the questionnaire data, the first question probed the issue of cost and its possible impact on the use of the simulation centre by undergraduate Building degree students.

The response was that even though the research undertaken in question 1 has shown that the use of the simulation centre in the undergraduate Building degree courses is recommended by the three groups of respondents, the practical issue of cost prohibits the integration across all undergraduate levels, for all students. This response does not rule out the use of the simulation centre, it simply means that it will not be integrated into the curriculum for all students' at all three levels. However, this response goes slightly against the quantitative data, which suggested that all building degree students within the existing degree curriculum should use the centre. As a consequence a proposal was formulated where the use of the centre would be offered to all building students at level 1 and only construction management students at level 2 and 3. This issue reconfirms the qualitative data obtained from the staff questionnaire where, on numerous occasions, the issue of cost and its possible impact arose.

The response to the cost of using the centre raises another issue highlighted by the qualitative data, curriculum time. The response was that the impact at level 1 would be limited as the aim would be to only offer a short, brief taster session to the simulation experience. In addition, by limiting the use of the centre to just construction management students at level 2 and 3 the impact on curriculum time could be reduced. The centre would be used to help deliver, or assess, content from one construction management module at level 2 and 3. This means that a close look at the appropriateness of possible modules needs to be undertaken and links to the final sub-section of the question posed, appropriate module choice.

The quantitative data produced from the questionnaire resulted in modules that actually had low suitability for use in the simulation centre. The response was to look at the learning outcomes of modules to identify links with the key competencies that the simulation centre aims to deliver. As the centre aims to deliver 'soft' skills the most suitable module at level 1 was Economics and Communication, focusing on the key competency of 'communication'. At level 2 and 3 the specific construction management modules of Management Principles followed by Construction Management Studies were identified as closely linking with the competency of 'team and people management'.

It is now possible to consider the outcome of the data collected in relation to the main aim of the research: to investigate the possible use of the simulation centre in the Building degree curricula at Coventry University.

The answer to the question can be broken down into four categories:

1. the use of the simulation centre for all undergraduate Building degree students is deemed worthwhile by all three parties questioned (staff, students and employers)

2. the cost of the use of the simulation centre makes it prohibitive for all students to use it at all levels of their current undergraduate Building degrees
3. additional concerns regarding embedding the simulation centre within the current undergraduate Building degree curriculum focused on the amount of undergraduate Building degree curriculum time the simulation centre might need. This has been reduced by limiting the amount of time students use the centre at level 1 and limiting the students using it at the other levels
4. suitable modules at all three academic levels are not clear from the data. This has been revisited to look at specific learning outcomes and the competencies the centre will aim to deliver.

From the data obtained, there is a conflict whereby all parties questioned see the use of the simulation centre as a positive way forward but the cost of using the centre makes embedding its use for all students at all levels prohibitive. Therefore the use of the centre is being limited and varied at different levels and is the basis for the course proposal, presented in the following section.

Recommendations and proposal

The proposed programme of the use of the simulation centre is shown in Table 1.

Table 1. Programme

Level	Course	Length of course
1	All Building students	½ day
	ACT-UK Competency – Communication **University module** – Economics and Communication **Learning outcome** - Apply a range of communication techniques currently used in the construction sector.	
2	Construction Management students only	2½ days
	ACT-UK Competency – Team and people management **University module** – Management Principles **Learning outcome** - Identify and appraise factors affecting relationships between individuals in organisations	
3	Construction Management students only	2½ days
	ACT-UK Competency – Team and people management and leadership. **University module** – Construction Management studies **Learning outcome** - Articulate the use of Alternate Dispute Resolution methods such as mediation in addressing construction disputes	

The programme at level 1 (for all Building students) will be a short half-day taster to the simulation experience that focuses on providing the students with an initial form of site experience and test of

"soft" communication skills. At level 2 and 3 the course would be two and a half days in length, exclusively for Construction Management students. The longer period of time would allow for greater experience and provide students with valuable training through an activity led approach. The structure and detail of an example scenario is shown in Table 2.

Table 2. Example structure and scenario – level 2

The structure of each day is split into two sessions. Prior to the first session the students are given a short briefing session on the particular project the scenarios are based on, either a housing or high-rise project. Each training session lasts 2.5 hours and contains the following:

- a skills input session e.g. managing people (45 minutes)
- briefing of simulation session outlining the exercise scenario to be undertaken (15 minutes)
- simulation session where the learner undertakes the exercise scenario and deals with a simulation scenario (1 hour)
- feedback (30 minutes)

The skills input session is aimed at providing any necessary underpinning knowledge that could be used when undertaking the simulation session. The briefing outlines the specific exercise that the students have to undertake in the simulation session (e.g. checking Health and Safety paperwork) but does not provide any detail regarding the simulation scenario that will also be undertaken. This is to ensure that the simulation process remains as realistic as possible. During the simulation session the learner undertakes the outlined exercise. Whilst undertaking the exercise a simulation scenario will also be started (e.g. to find out how the student reacts to a serious health and safety issue). The beginning of the scenario could be that the site manager's foreman (played by an actor) comes into the site office and explains to the student (in the role of the site manager) that someone has been seen climbing from one mast climber to another at Level 10. To make the simulation effective a number of parties would be involved in the scenario, including a foreman and subcontractor (played by actors) and health and safety representatives who could be contacted via the telephone. Expected outcomes as a result of the simulation scenario would be that the student stops the work immediately, contacts appropriate health and safety representatives, contacts HSE, records what has happened or begins the health and safety reporting process. The main aim of the simulation session is to see how the student reacts to and manages this scenario and not the exercise scenario that was outlined in the briefing session. Such a simulation scenario would allow the student to show competency in team and people management along with problem solving and risk management. This would be discussed in the feedback session (in groups and on an individual basis), focusing the students on their strengths and how they might have undertaken the scenario differently by using knowledge gained from the skills session.

In addition to the activity led simulation sessions, students will undertake skills input sessions covering team working, performance management and people management. These sessions link with the skills gaps identified by professional bodies and also the CIOB Educational Framework Skills Learning Outcomes and should therefore help students commencing work in the construction industry.

Conclusion

The establishment of the ACT-UK simulation centre has raised a key question as to whether and how the simulation centre could be used in the delivery of Building degree curricula. The findings suggest that at present it seems that it should not be offered to all students at all levels within the undergraduate Building degrees at Coventry University. However, that is not to say that the use of the simulation centre is not deemed worthwhile. The case study data collected from all parties (i.e. staff, students and employers) show that the use of the construction simulator is seen as a positive step forward in construction teaching and should be offered in some form to all undergraduate Building degree students at Coventry University. A proposal has been established to develop a programme that would be offered to all existing undergraduate Building degree students at level 1 and just Construction Management students at level 2 and 3.

To summarise, the research has shown that the use of technology to deliver construction training is deemed worthwhile for the teaching of construction students. However, the use of such technology is not without problems, the major issue being that the cost may at present be too high to offer it to all students at all levels. Nevertheless, the case study has offered a lesson for the adoption of a new learning technology to enhance the student learning experience within the higher education context.

References

ACT-UK. *ACT-UK simulation centre.* Available from: http://www.act-uk.co.uk/ [accessed 18 March 2010].

Bell, J. (1999) *Doing your research project.* Buckingham: Open University Press.

CIOB (2009) *Education framework*. Available from: http://www.ciob.org.uk/education/framework [accessed 18 March 2010].

De Vries, B., Verhagen, S. and Jessurun, A.J. (2004) Building management simulation centre. *Automation in Construction*, **13** (5), 679-687.

Horne, M. and Hamza, N. (2006) Integration of virtual reality within the built environment curriculum. *ITCon,* **11**, 311-324.

Macdonald, R. and Savin-Baden, M. (2004) *A briefing on assessment in problem-based learning*. Available from: http://www.bioscience.heacademy.ac.uk/ftp/Resources/gc/assess13.pdf [accessed 18 March 2010].

Proverbs, D. and Gameson, R. (2008) Case study research. In Knight, A. and Ruddock, L. (eds.) *Advanced research methods in the built environment.* Oxford: Blackwell Publishing.

Stewart, D. (2007) *Better than the real thing*. Available from: http://www.building.co.uk/story.asp?storyCode=3081720 [accessed 18 March 2010].

Stothers, N. (2007) *The use of virtual reality simulation in the education and training of construction managers. Are the British "going Dutch"?* Available from: http://www.scribd.com/doc/6559542/The-Use-of-Virtal-Reality-Simulation-in-the-Education-and-Training-of-Construction-Anagers [accessed 18 March 2010].

Taylor, J. (2008) *Building in virtual reality*. Available from: http://www.cnplus.co.uk/building-in-virtual-reality/1050081.article [accessed 18 March 2010].

The Open University (2007) *E891 educational enquiry study guide.* Milton Keynes: The Open University.

Yin, R.K. (2003) *Case study research: design and methods*. 3rd edition. London: Sage Publications Ltd.

Contact details

Mr. Stephen Austin. BA (Hons) Architecture, PGCE, MSc. Management for Construction

Senior Lecturer in Construction, Coventry University, UK

Tel: 0247 688 8297 E-mail: s.austin@coventry.ac.uk

Dr. Robby Soetanto. BEng Civil Engineering, MEng in Construction Engineering and Management, PhD in Construction Management and Engineering, PGCert

Senior Lecturer in Construction Project Management , Coventry University, UK

Tel: 0247 679 5189 E-mail: robby.soetanto@coventry.ac.uk