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### *ACT-UK Simulation Centre: use within the Department of Civil Engineering, Architecture and Building*

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# **ACT-UK SIMULATION CENTRE: USE WITHIN THE DEPARTMENT OF CIVIL ENGINEERING, ARCHITECTURE AND BUILDING**

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## **ABSTRACT**

The Advanced Construction Technology Simulation Centre (ACT-UK) is an innovative facility for training future construction managers, enabled by a semi-immersive virtual reality model of construction sites. As part of the degrees at Coventry University, four 2-day training sessions were conducted and attended by nearly 80 students. A reflective account of the process of formulating the training programme is reported in this paper. It highlights the process of running two pilot courses to help formulate the proposed training sessions. In addition, questionnaires were taken to identify the necessary ‘soft’ skills that the training process delivered. Comments on how the courses altered during their delivery are also described. As such the case study offers a lesson on the adoption of an innovative new problem based learning process to enhance the student learning experience within a higher education context.

## **INTRODUCTION**

ACT-UK is a national centre of virtual reality simulation located at Coventry University Technology Park. ACT-UK uses the latest technology to train construction trainees through

the pedagogy of problem-based learning (PBL). The centre delivers scenarios with all the pressures, issues and interruptions that are experienced on a real building site and incorporates a philosophy that the students 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 real situation and interact with actors as necessary (Horne and Hamza, 2006). The centre is unique in the UK and is based on the VR technology 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 complete specific construction related tasks whilst actors play a variety of roles that a construction manager might encounter during a typical day (Stewart, 2007). As suggested by Macdonald and Savin-Baden (2004), 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 learners 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 simulation centre offers training which complements existing education and training programmes and therefore its use was considered appropriate for the existing undergraduate Building degree programme at Coventry University. However, the centre does **not** offer full education but focuses on problems that require ‘soft’ skills that can be developed through the experience (Taylor, 2008). 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, identified competency and skills categories which were deemed the most important for a UK site manager (Stothers, 2007), these being, leadership; planning and organisation; monitoring and controlling performance; problem solving and risk management; team and people management; and communication.

Previous research (Austin and Soetanto, 2010) has been undertaken regarding the use of the centre to enhance the learning experience of undergraduate students within the

Department of Civil Engineering, Architecture and Building at Coventry University. The findings suggested that ACT-UK training should not be offered to all students at all levels within the undergraduate Building degrees. However, that is not to say that the use of the simulation centre was not deemed worthwhile. The case study data collected showed that the use of the construction simulator was seen as a positive step forward in construction teaching. Issues regarding cost, available curriculum time and appropriate modules in which the simulation centre could be embedded meant that it was not possible for all students to use the centre at all degree levels. In direct response to this conflict, a proposal was established to develop a programme that would be offered to Construction Management students at level 2 and 3. This case study explains the development and implementation of this programme.

### **Programme development**

Having established which course would be using the centre the first stage in the development was to establish which constituent modules within the Construction Management degree would have the most synergy with ACT-UK. This process was simplified by there only being one module at level 2 and 3 that was undertaken solely by undergraduate Construction Management students: -

- Level 2 – Management Principles and Statistics
- Level 3 – Construction Management Studies

As both modules have strong management content, a key focus of the simulation centre, the choice of these two modules was deemed appropriate. The next stage in the process was to ensure that the use of the centre would be suitable within these two chosen modules. To facilitate this process a review of the learning outcomes and their suitability for use in the centre was undertaken, in conjunction with the skills identified above, that the centre delivers. The process of matching the module learning outcomes and centre's competency skills was undertaken during a meeting with the centre's manager and a designated ACT-UK co-ordinator from the department. The co-ordinator had previously helped to develop the training activities and scenarios used within the centre and therefore had prior knowledge of possible training activities. For the level 2 module the following learning outcome matched closely with the centre's competency skills. "Identify and appraise factors affecting relationships between individuals in organisations". At level 3 the learning outcome that most closely

matched was “Articulate solutions in addressing common construction problems”. These two learning outcomes were chosen as they closely match with the centers competency skills of leadership, team and people management and communication. Having decided on a focus for the training programmes the next stage, during the meeting, was to decide which of the centres training scenarios could best deliver these learning outcomes. A review of the 100 possible training scenarios that the centre has available was undertaken to ensure that those chosen focussed on the three competency skills of leadership, team and people management and communication.

The centre operates its training programmes on a maximum of 2 simulation sessions a day. During each simulation session there is 1 main training scenario and usually 2 smaller scenarios. These scenarios are snap-shots of real-life construction site situations, and require the trainee to interact with various actors who introduce the site problems. By referring to information presented to them and interacting with the actors, the trainees need to make decisions, and will also receive feedback once the session ends. The interaction with the actors represents the most important phenomenon in the process as it can unfold the trainees’ ‘soft’ people management and communication skills and demonstrates their inherent personal attributes such as empathy, confidence, decisiveness and assertiveness. Based on the feedback, the trainees can reflect on their behaviour during the sessions and learn from the reasons why they have behaved in a certain way when faced with a specific construction site scenario. Such a cognitive process will enhance their people management skills and promote deep learning due to their engagement with the scenarios. The following training scenarios were chosen.

Level 2	Level 3
<p><b>Simulation 1</b></p> <p><i>Main</i> – Damaged vapour barrier.</p> <ul style="list-style-type: none"> <li>• Details – the breather membrane has been damaged on a plot. The site manager has to organise the repair and to ensure the correct laps.</li> </ul> <p><i>Secondary</i> – Carpenter walking off the street looking for work, ground operative complaining about their goggles</p>	<p><b>Simulation 1</b></p> <p><i>Main</i> – Foundation problem.</p> <ul style="list-style-type: none"> <li>• Details – ground worker comes to the site office because foundations to a certain plot have encountered loose made-up ground and a solution is needed</li> </ul> <p><i>Secondary</i> – site worker late for induction, visit from the quantity surveyor.</p>
<p><b>Simulation 2</b></p> <p><i>Main</i> – Clients kitchen.</p> <ul style="list-style-type: none"> <li>• Details – purchaser has visited his kitchen and notices it is incorrectly installed. He refuses to complete until the layouts is as per his drawing</li> </ul> <p><i>Secondary</i> – Project manager asking for completion dates, site foreman asking to work on a Sunday</p>	<p><b>Simulation 2</b></p> <p><i>Main</i> – Unsafe use of scaffolding.</p> <ul style="list-style-type: none"> <li>• Details – bricklayer foreman called to the office to see who changed the scaffold and then used.</li> </ul> <p><i>Secondary</i> – Plasters plasterboard has been damaged, an angry neighbour.</p>

Table 1. Scenarios identified for each level

All the scenarios chosen for level 2 have a strong focus on team and people management to meet the specific learning outcomes identified. The level 3 outcomes have a strong focus on leadership to again meet the specific learning outcome. Both levels have strong communication focus need for working within construction.

### **Pilot**

Prior to the courses being undertaken it was felt necessary to undertake a series of pilot sessions to see if the scenarios chosen were appropriate. These pilot sessions were limited in spaces, and were open to all final year building degree students, but excluded Construction Management students. The pilot courses were for half a day and therefore only had 1 simulation. The simulation piloted was level 3, simulation 2, unsafe use of scaffolding, plus the angry neighbour. After each pilot course a review was undertaken and discussion was undertaken with the delegates to gauge their experience and try and make sure the scenarios were correct. An area of clear consensus was that the proposed use of the centre was a rewarding and valuable experience for the students within the construction industry.

*“..the experience is enormous... a lot more was learnt”*

*“...used good real life examples...definitely do it again!”*

However, there was one area that the students felt could be improved and this was the ability to review the process and discuss the consequences of the decisions that they took.

In addition to the verbal feedback obtained, a questionnaire was issued. The aim of the questionnaire was to ascertain the student’s views on the skills being developed in the centre and how they rated their own performance in these skills.

Skill descriptor	Level of importance							
	Very		Fairly		Low		None	
Communication skills	90%	45%	10%	50%	0%	5%	0%	0%
Leadership	85%	40%	15%	45%	0%	15%	0%	0%
Team working & team building	70%	70%	25%	25%	5%	5%	0%	0%
Problem solving	90%	50%	10%	25%	5%	5%	0%	0%
Planning and organisation	70%	25%	30%	55%	0%	20%	0%	0%
Monitoring and controlling performance	60%	25%	35%	55%	5%	20%	0%	0%
	Importance with career	Own rating ability	Importance with career	Own rating ability	Importance with career	Own rating ability	Importance with career	Own rating ability

Table 2. Skills analysis

Out of the 6 competency skills a high majority of all the students rated each one as being a very important skill in helping them prepare for careers in the construction industry. In relation to their own ability the majority of the students rated themselves as only having a fair ability in the skill. However, there was one exception to this, teamwork. This could be somewhat explained by the nature of the degree programmes the level 3 pilot students were undertaking. Their courses contain an integrated project module, which they were currently undertaking and which heavily focuses on team work and team building.

What was drawn from the pilot feedback and questionnaire is that the students were extremely positive about the training within the simulation centre and identified that the skills the centre focuses on are very important in the construction industry. In addition, they also showed that they felt there was a clear area of developmental opportunity that undertaking training in the centre could start to address.

Following the two pilot courses a decision was taken to run the proposed courses, for level 2 & 3, using the scenarios previously outlined, but to also address the issue of being able to review the process and discuss the consequences of the decisions taken.



**Course delivery**

The first issue to decide upon was the number of courses to run. The ACT-UK centre works best when around 5 or 6 site huts are being used at the same time. The reason for this is that if there are more site huts being simultaneously used, the ability of training supervisors to give effective feedback is reduced, as there is too much to observe. In addition, as the training is a new facility that the students hadn't experienced before, the decision was taken to allow the students to initially work in pairs for the first day and work independently on the second day. This decision also replicated 'real-life' site management where individual and team work ability is vital. As the training is a semi immersive process it can be very tiring mentally, the centre recommends that no simulation session last longer than 90 minutes. This allows for 2 simulations to be run in the morning and two in the afternoon, resulting in more students being trained. As a consequence of this information it was decided that there would be one level 2 course of 14 students and three level 3 courses, with each occurrence having 22 or 23 students. The level 3 course structure is shown below.

<i>Day 1 – ACT-UK</i>	
9.00 – 9.30 – Arrival, introduction to course	
9.30 – Briefing of the project and Familiarisation of simulation hall and site huts	
Simulation 1	
Group A (10 students in pairs) 10.00 – Briefing of simulation session 10.15 – Simulation exercise in pairs 11.15 – Feedback from actors 11.30 – Lecture & Coursework introduction	Group B (12 students in pairs) 10.00 – Lecture & Coursework introduction  11.30 - Briefing of simulation session 11.45 – Simulation exercise in pairs 12.45 – Feedback from actors
Simulation 2	
Group A (10 students in pairs) 2.00 – Briefing of simulation session 2.15 – Simulation exercise in pairs 3.15 – Feedback from actors 3.30 – Observation	Group B (12 students in pairs) 10.00 – Observation  3.30 - Briefing of simulation session 3.45 – Simulation exercise in pairs 4.45 – Feedback from actors
<i>Day 2 - ACT-UK &amp; Coventry University</i>	
11.00 – 1.00 – Feedback and discussion – review of previous days simulation and preparation of final simulation process	
2.00 – Simulation exercise individually and observation	
4.00 - Feedback	

Table 3. Course structure

The briefing outlines the specific exercise that the students have to undertake in the simulation session. These are related to the specific construction site, but were also related to

prior learning that the students had undertaken within the module and included relevant site management issues (e.g. checking Health and Safety paperwork). However, the exercise 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 the simulation scenario will also be started (e.g. to find out how the student reacts to a leadership, team and people management and communication issues). 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 there is a problem excavating the ground for a certain plots foundations (Level 3 – Simulation 1). To make the simulation effective a number of parties would be involved in the scenario, including a foreman and subcontractor (played by actors) and structural engineering representatives who could be contacted via the telephone. Expected outcomes as a result of the simulation scenario could be that the student stops the work immediately, contacts the company's structural engineer representative, discusses the situation with the site foreman or makes an uninformed decision. The main aim of the simulation session is to see how the student reacts to and manages this news 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 leadership and necessary on-site communication. During the rest of the training session the students would encounter two smaller site scenarios from the actors, linked to leadership, team and people management and communication issues, which also require action. Following the simulation there is a short feedback session by the actors, to the students in groups, focusing the students on their strengths and how they might have undertaken the scenario differently by using knowledge gained from the skills session.

The afternoon simulation sessions were devised as consequence of the feedback provided from the pilot courses. The students had commented that they wanted the ability to review the process. This was not fully achievable, however, a compromise was devised. When one group was being simulated, the students from the other group were given the opportunity to watch the first group of students going through the simulation process. They got to see the interaction between the students and the actors and therefore see and understand the consequences of the decisions that the students made. This process was then reversed. However, on the first course when group A were being simulated it soon became apparent that the students in group B, who were observing, thought that they had an advantage because

they knew the scenarios and problems that they were about to encounter. Therefore, a decision had to be quickly made regarding the second group and their afternoon simulation to ensure that it was still a valid learning experience. In consultation with the manager for the ACT-UK centre, the decision was taken that, though the second group would encounter the same scenario, it was possible through the actors to considerably alter the experience and therefore make the students react to the new experience and not the one they were expecting. The alterations were instead of the bricklayer foreman arguing that his workers hadn't altered the scaffolding (level 3 – simulation 2) to being totally agreeable but not really suggesting ways to help improve the problem. This difference, that is achievable through the actors, ensured that the students received the same scenario but had to react to different experiences.

The structure to the second day was also developed from the feedback where the students commented that they wanted to discuss the consequences of any decisions that they took. Therefore, the start of the second day was an open review of the previous day, undertaken as a group experience. The students, in their pairs, received feedback from the three supervisors who had monitored their performance from the control room. The feedback very much focussed on positive reinforcement. The students were advised on the consequences of the actions they had taken. It wasn't stated that it was wrong, just that different people had reacted in different ways and as a result had different outcomes. The students were asked to listen to other group's feedback and see whether they could learn from how other people had undertaken the process. Discussing the possible use of more imagination and passion to respond to the situation, rather than just relying on pure technical knowledge or authority/power further developed this. All six scenarios were reviewed over an approximate 2-hour period. Students made notes of the feedback to help with a coursework that had been set on their experience of using the simulation centre in relation to the module learning outcomes. At the end of the feedback process the students were introduced to the format of the remainder of the second day. Whereas the first day was undertaken in pairs, the second day was an individual experience. To help the students learn by reviewing their actions, the second day simulation was a repeat of the one of the first day scenarios (simulation 2). However, rather than one actor being involved the students had to deal with two actors. Whilst five students were being simulated all of the other students were in the control room observing. Once the first five had been simulated the next five undertook the scenario. The original plan was that they would all receive the same process, but after the changes need in the first day it was

decided that each group of five would receive a slightly different experience by altering the actions that the actors undertook. It ranged from a foreman refusing to get off his mobile phone whilst in the meeting, to disengagement and finally near physical confrontation between the two actors. Another change that was made was that when the first five students had undertaken the scenario instead of sending the next five straight in the first five were brought up to the control room so that all students were together. The observing students, along with the observing supervisors, then gave verbal feedback to the first five students, in a similar process to what had been undertaken in the morning.

**Evaluation**

To ascertain the effectiveness of the training the students undertook two questionnaires. The first questionnaire was undertaken before the start of the training, during the introduction, the second after the training. Both used the same questions to evaluate the student’s response to the training that had just been undertaken.

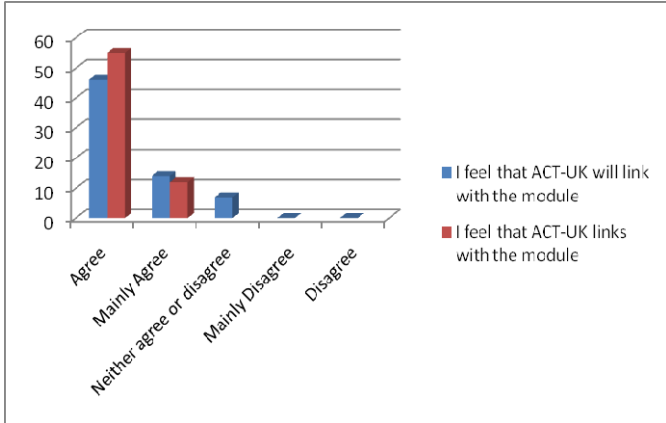


Figure 1 – Linkage to Level 2 & 3 modules (Number of responses)

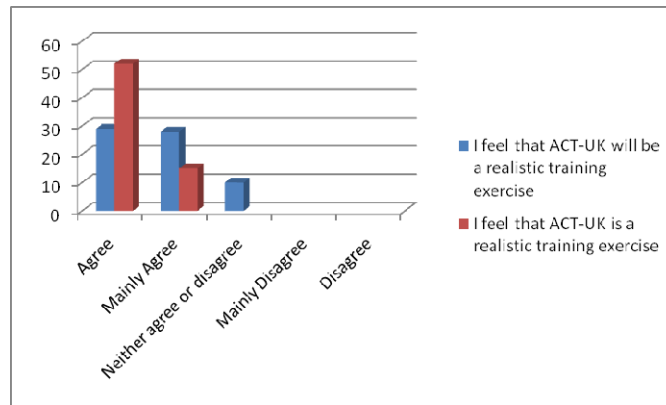


Figure 2 – Realism of the ACT-UK training (Number of responses)

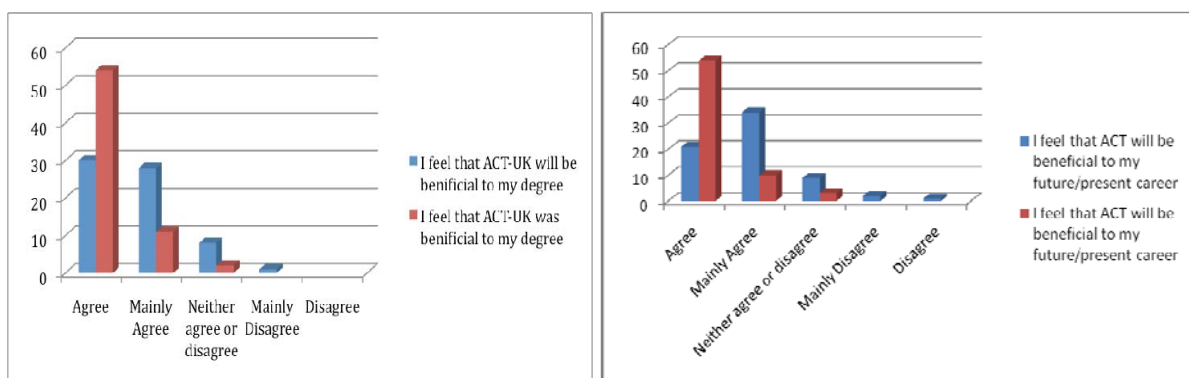


Figure 3 – Benefits of the ACT-UK Training (Number of responses)

Students thought that the centre was going to link well with their respective construction management modules. After the training this rose to 80% of the students agreeing and no student disagreeing. The realism of the training also rose after the students had experienced it, to 77% with again no students disagreeing. Regarding the benefits of the training this rose to 81% for both questions. In addition to the questionnaire, as part of the modules assessment the students were asked to write a report on their ACT-UK experience. Three questions were asked. How did the training go?; What was positive and what was negative about the experience?; How useful was the training in terms of both your current BSc. course and current and/or future development. The first question relates the ACT-UK experience to the module learning outcomes and especially the centres competencies of leadership, team and people management and communication. Below are a sample of responses the students produced in relation to these competencies.

*“I got to learn what leadership is with respect to the organizational aspects of managing human tendencies...”*

*“This training improved our thinking as a person, making me aware of how to deal with things when they arrive unexpectedly on site. Handling pressure and solving issues at the same time boosted my confidence”.*

*“I then realised that communication was the key to learning in the simulated environment...”.*

*“The feedback given by the actors on the concepts of communication skills, teamwork and leadership skills, individually were very informative”.*

The second and third questions asked reinforced the data from the questionnaire. All the data collected showed that the students saw the training undertaken in the simulation centre as a valuable, relevant and beneficial experience. In addition to the questions students were able to provide summary comments on the training. These were extremely positive.

*“Overall I thought this was a good course and gives students a heads up when starting a job in the real world”*

*“ I feel as if I learnt more about my own strengths and weaknesses than any other University event”*

The results of these comments, and the data received from the questionnaires, has meant that the use of the ACT-UK centre is planned to be used next academic year, and, as a consequence, module descriptors have been amended to reflect this integration.

## **Conclusion**

To conclude, the use of the ACT-UK centre within the construction management modules in the Department of Civil Engineering, Architecture and Building has been received extremely positively. The development of the course provided has been closely linked with the relevant module learning outcomes and centre competencies. A pilot process has been undertaken to ensure the training scenarios chosen are effective and relevant. After the pilot courses the new training courses were implemented across the two modules. As part of the review, data and views were collected from the students that showed an extremely positive and valuable problem based learning experience that met the learning outcomes selected from the specific modules.

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