

Real-Time Simulation Training with Construction Management Students; a Case Study of an Overseas Partnership

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The construction industry requires a complex mix of technical and soft skills to manage the people, resources, and money to complete a project in today's built environment. Traditional construction management education focuses on the technical foundation skills. Recent efforts are being made to further develop communication, problem solving and team building skills. While CM programs look to create classroom programs to build these competencies, on the job training, internships, co-ops, and student competitions have proven some of the best options to help build these soft skills. The questions rise: Can we recreate the real world in our classrooms? How do we train problem solving, teamwork, and the ability to make quick decisions? All of these have driven educators around the globe to focus on recreating the real-world through simulations and experiential learning. Simulations can be in the form of role playing, case studies, competitions, and industry scenarios. This paper will describe the success a European university (Coventry University) has had in building a simulation program like nothing in the USA. Through a generous partnership, Purdue University and six of their students were able to shadow this program to learn best practices. This paper is a case study of the program and overseas collaboration that both programs would like to share with other CM programs. Many of the best practices and lessons learned can be incorporated into any course or curriculum.

Key words: simulations, experiential learning, competencies, real-world, scenarios

Introduction

Coventry University saw the need to increase experiential learning with all of the students on their campus. It was not isolated to just CM students. Additionally, the local construction industry was seeking new and innovative ways to help improve the problem solving skills of their employees and their project teams. The solution was a campus wide partnership to build a program that could recreate real-world scenarios for use by industry and academia. This would require a flexible facility that could be utilized by more than one discipline. Manufacturing and emergency preparedness are just some of the other fields utilizing simulations. The resulting project was a flexible simulation center that would be built in a metropolitan area. It would be convenient for students with nearby mass transportation and allow parking for industry partners to readily participate there efficiently.

Over the last nine years, Coventry has refined their learning objectives and the resulting program to build these skills. This paper will outline the program background, learning outcomes, typical components of a simulation that can be used with industry or academia, lessons learned, and areas of future research. This paper is the case study of a partnership with Purdue University (ASC member) and Coventry University. The partnership was further reinforced while Brad Benhart with Purdue was a visiting scholar at Coventry in 2017. The desired outcome is to increase the collaboration efforts and increase the ASC footprint with another program.

Literature Review

Contemporary literature covering undergraduate construction education reflects an ongoing concern with fostering the soft skills of students. Related studies include the prominent study of Bloom's taxonomy (Bloom et al.,1956). Blooms includes the six levels of knowledge, comprehension, application, analysis, synthesis, and evaluation. The levels progress with knowledge being the lowest. Climbing the levels requires active learning. Blooms is now the basis for the new American Council for Construction Education (ACCE) student learning outcomes.

Looking for the higher levels of Bloom's taxonomy, educators have turned to simulations. Simulations as part of active learning have proven effective and engaging (Rokooei, Goedert, and Woldesenbet, 2017). Rokooei, Goedert, and Woldesenbet highlighted that there is a statistical difference between pre- and post-situations. Information through active learning exercises with immediate feedback is highly desired by millennials, highlighted in satisfaction surveys (Burgett, 2016). Research has also spurred the development of Internet-based Construction Management Learning Systems (ICMS) that utilizes active learning approaches to bridge the gap between the classroom and construction site (Sawhney, Mund, and Koczenasz, 2001). Simulation success factors have also been analyzed: 1) taking into account human factors and feedback effects triggered by them; 2) focusing on tradeoffs associated with managerial decisions and construction policies; and 3) developing an easy-to-use standalone tool that runs on any platform without other supporting programs (Park, Chan, and Ingawale-Verma, 2003)

Strategies and Methods

Facility

The simulations are delivered in a designated facility that can recreate many types of spaces. This facility is multi-disciplined, requiring use by numerous academic learning units and industry partners. In addition to the construction industry, it is utilized for emergency preparedness, manufacturing scenarios, multiple government entities, tech firms, and any other scenarios that require both teamwork and one-on-ones. One day it might be a construction site; the next day it is an oil drilling platform. Mock interviews and team analysis can all be accomplished here. The facility is a high bay space, 24' tall with no windows. At one end is a virtual cave, 30' x 9'. Surrounding the space are eight office cabins and two team cabins. Cabins are similar to construction trailers and mimic the same office a superintendent would have on a jobsite (Figure 1). The space can further be customized with background noise appropriate for the scenario. Airplane traffic, construction noise, emergency sirens are some of the sound offerings.

Figure 1: Typical Job Cabin

Figure 2: Simulation Control Room

Monitoring and recording is captured throughout the facility. All cameras and audio are transmitted and recorded in a control room (Figure 2). The control room is outfitted with monitors and the capability of four reviewers to be monitoring participants and scenarios in each office (Figure 3). This will be further explained later in the paper.

The space is further enhanced with a virtual reality (VR) parabolic screen (Figure 4). The VR software, called XVR, can be built to create an entire jobsite with exterior and interior perspectives. It also has the capability of daylighting and weather. A mock storm can be created complete with the after effect of accumulating water. The screen can also access Google Earth, helpful in creating scenarios anywhere in the world.

Figure 3: Recording Software

Figure 4: Parabolic Screen with Controller

"Failing Safe" – The Process of Creating a Scenario

1. Participant Preplanning – Intentionally, students have little to prepare. They are provided a clear start and end time (typically 9am - 5pm). The lack of details is often met with resistance. Participants want to know what they are going to be doing to be prepared, and the unknown concerns them. Nervous questions are handled with a reassuring message that there is no pre-work and that they should arrive ready to participate. Concerned that they will be graded, students tend to be more anxious than industry participants.

2. Scenario Preplanning – The Coventry University Sim Centre has a library of scenarios, all of which typically take 5-20 minutes for a student to reach a potential solution. Students will participate in seven scenarios (five main and two practice) in one-on-ones situations. The delivery team will meet several days ahead of time to determine what scenarios might work best with the group of students. Background, language skills, level of education, and work experience can affect the types of scenarios selected. Industry partners will dictate their scenario selections by type of work and level in the company.

3. An example Scenario – The participant is the assistant superintendent on their first day on the project. The superintendent has had to leave unexpectedly and the participant is left in charge. Example Scenario – A laborer (actor) enters the cabin and indicates that workers found drug paraphernalia in one of the partially complete buildings. It looks as if someone broke into the jobsite over the weekend and had been cooking some form of drugs. There are syringes, a smaller burner, unknown residue, spoons, and several containers of unlabeled solution. The area is actively under construction with workers in the area. The laborer asks what they should do. The participant is then reviewed on how they handle the situation.

4. Actors – The term actors might seem excessive. "Why can't faculty play the roles in the scenarios?" They certainly can. However, after watching trained actors, who have never met the students, perform, it is easy to understand the value. The actors are dynamic individuals who understand the scenarios (Figure 5 and 6). Their ability to adjust and change character was impressive. Along with costume changes, they could quickly switch characters to another scenario. The key component was that the students had never met them before.

Figure 5: Scenario Example

Figure 6: Actors

5. Reviewers – During the scenarios, reviewers are watching each situation. Each reviewer is partnered with an actor as they progress through the participants as they perform the same scenario. During this time, reviewers are taking notes. Each scenario has a feedback form with typical reactions of the participants. These review forms have been created and modified with typical participant outcomes (Figure 7). They also include a matrix of how each outcome and action can help enhance targeted outcomes and competencies (Figure 8).

Simulation	Date	Site Hut	Name

Scenario Drug paraphernalia found in plot		
Possible Outcomes		**Notes**
1. Does not believe operative - needs to see it for him/herself		
2. Blames neighbours/operatives - begins random drug testing		
3. Police become involved		
4. Phones for help.		
5. Other		
Possible Actions		
1. No action at all		
2. Tells operative to make the area secure - no access		
3. Tells operative to clear it up		
4. Stays calm.		
5. Informs Contract Manager and H&S Manager or Police		
6. Asks relevant questions.		
7. Gives clear instructions		
8. Other		

Figure 7: Notes, Outcomes and Actions

Simulation	Date	Site Hut	Name

1. Leadership
2. Understanding client needs and contract requirements
3. Planning and organization
4. Monitoring and controlling performance
5. Problem solving & risk management
6. Team and people management
7. Communication

	1	2	3	4	5	6	7
Possible Outcomes							
1 Does not believe operative - needs to see it for him/herself	x		x				x
2 Blames neighbours/operatives - begins random drug testing				x	x	x	
3 Police become involved				x	x		
4 Phones for help.		x					x
5 Other							
Possible Actions							
1 No action at all							
2 Tells operative to make the area secure - no access	x			x		x	x
3 Tells operative to clear it up							
5 Stays calm.	x						
7 Informs Contract Manager and H&S Manager or Police	x			x		x	x
8 Asks relevant questions.					x		x
9 Gives clear instructions							x
10 Other	x						

Figure 8: Desired Competencies

6. Resources to solve the problem – Each cabin is equipped with a phone and a complete phone directory that coincide with the project. Additionally, the plans and specifications are in the room. Scenarios are often open ended after the actor leaves the room. The student is left to solve the problem and follow up as necessary. This might require a site visit (VR screen), several phone calls and often times a follow up visit with the actor. When they use the phone in the office it rings back to the control room where the reviewers are able to see which stakeholder the participant is calling. For example, if a participant calls the structural engineer, it will ring in the control room and the display will indicate the office number and structural engineer. The reviewers are able to pick up the phone in character, "Hello, XYZ Structural Engineering." Each of the scenarios is designed that the participants will have to reach out to stakeholders and resources to attain a reasonable solution. There is no perfect solution for each scenario. They are designed such that there could be multiple solutions.

7. Filming – The recording system is made by Bosch and allows for editing and cutting. Each office is recorded digitally with both audio and video (Figure 9). It also records when participants are talking to themselves. At the completion of the day, the team edits the videos for each student to include any interaction he or she has had during the simulations. Idle time working in the office is removed. These recordings are used on day two of simulations. Each student's recording is saved to a flash drive. It should be noted that students sign waivers indicating that they will not show their videos to other students. More importantly, the waiver requires that they will not post any video on the internet or on any social media.

Figure 9: Example View

8. Circulation – These scenarios are both mentally and physically draining on the participants and the actors. The program typically divides a class into two groups that circulate in and out of the simulations. When one group is in simulation, the other group is working on a team project or receiving feedback. The team projects are also focusing on problem solving, and communication skills in a group environment (Figure 10). Similar to the scenarios, the groups are provided a variety of resources to utilize for their projects. Team projects are not meant to have perfect solutions. An example of a team project is to create a presentation about construction management for elementary students who want to learn more about the industry. Another example is to develop a site specific safety plan for a project. Industry partners have also provided company specific team projects.

Figure 10: Student Feedback

9. Day #2 Instructor Feedback – Participants return one week after their initial simulation. This day they are again separated into two groups. One group receives detailed feedback from their day #1 experience (Figure 11). An instructor leads the roundtable discussion. Students are again encouraged to be open to feedback and suggestions. They are asked which scenario video they would like to review with the class. This is often met with humor and settles into genuine curiosity to help one another. The group is prompted with questions. “How could Emily have reacted differently in this situation?” “Is there a way Ian could have controlled his emotions?” After the roundtable review, each students gets specific feedback from the instructor. Additionally, they receive their written review forms for each scenario and their flash drive with their videos.

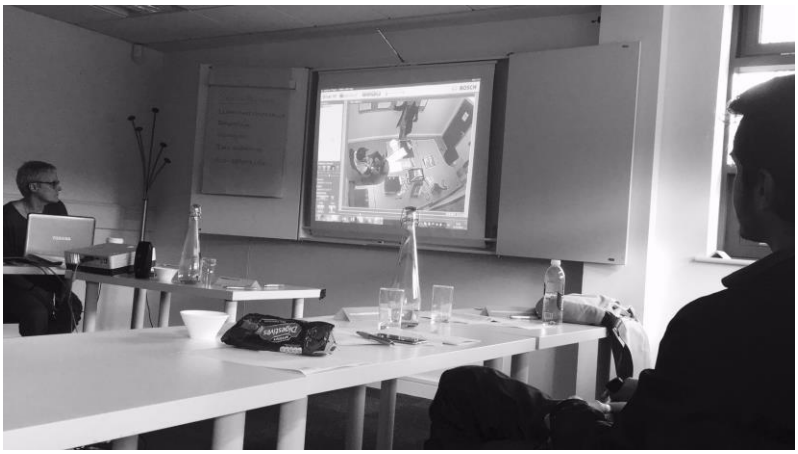

Figure 11: Student Feedback

10. Students as the Reviewers – The second group is assigned to the simulation control room. They are placed in an order of who will go through the scenario first, second, and so on. While the first student goes through his/her scenario, others watch and listen from the control room (Figure 12). Upon completion, the actors and participants return to the control room for actor, instructor, and student feedback (Figure 13). This portion of the program can provide some of the most valuable insight. Another student is then selected and goes to an office for similar scenarios. Typically, the second student feels more confident because of the feedback and ability to see the first student's performance in what they think is going to be the same scenario. While the scenario remains the same in theory, the delivery and emotions of the actors are changed to create a unique situation. Again, the participants and actors return to the control room for feedback. The students then provide feedback for one another. The added changes to the same scenario create robust dialogue on how best to resolve the issues. As opposed to the first day, students are now able to use the initial feedback to better manage the challenges of the new scenarios.

Figure 12: Students Viewing Scenarios

Figure 13: Peer to Peer Feedback

11. Wrap up – At the end of the second day, students are excited about their progress. A stern warning is issued to the participants that the key to success for future students is that the scenarios and simulations are not revealed to others. It is worth noting, this did not happen during any of the scenarios observed. Veteran reviewers indicated that it has happened in isolated instances. They indicated that when someone has early knowledge about a scenario, it is clearly obvious.

Unique Aspects
Feedback and Reflection

While the VR is eye catching and often the focus of attention, the real value of the simulations are the problem solving exercises for participants with feedback and visual examples. Few professions provide video critique of oneself in the workplace, let alone, in a stressful situation. These simulations are becoming more widely used by both academia and industry partners.

In summary, students receive four forms of feedback.

- Actors – Those "in" the scenarios provide the students with individual feedback on how they did and their ability to solve the problem from the person directly affected.
- Reviewers – They receive feedback from outsiders reviewing each scenario.
- Peers – Student feedback.
- Personal Reflection – see further detail below.

Personal reflection papers provide a time for the student to recognize their strengths and weaknesses in how they problem solve and their communication style. Their self-awareness improves and they continue to work on their related competencies. Following the simulations students are often seen as better team players and more confident during class presentations and on internships.

How Can this Improve Construction?
Positive Outcome

During the Spring of 2016 six students from an Purdue University traveled to Coventry England for a semester to study abroad and take courses at Coventry university. While there they participated in the simulations. In a debriefing meeting, one student described himself as "over confident." His classmates jokingly called him "cocky." During the scenarios he resorted to behaviors he would typically use in confrontations: standing up, getting close to the other person, raising his voice, swearing, and taking a position of dominance. While these behaviors might have worked for him in the past, they did not in the scenarios. Actors are instructed to be as aggressive, belligerent, and intimidating as the participants, with the exception of any physical contact. Again, this is mimicking the real world jobsites. In several situations, this participant's scenarios boiled into yelling matches, with poor results compared to his peers. Upon review of his video he came to a self-awareness that he has shared with his peers. "I never realized how stupid I look when I act that way." Almost a year and half later, that same student is now in the workforce and will often refer back to how those simulations have made him change his problem solving and communications skills. He is confident it has made him more successful.

Conclusions & Future Research

The establishment of this simulation program, coupled with this recent partnership, has opened an exciting door for research and further expansion. The opportunities to analyze pre and post aspects of this training can further develop models for return on investment (ROI). The ability to deliver simulations at varying years in a student's academic career is particularly exciting for the authors. Research and individual case studies is important for the future growth of simulations within industry. Training dollars are limited and every contractor wants to know that the time and expense of training will positively affect the financial success of the company. For Purdue Univeristy, this partnership has provided the catalyst to pursue a similar program in the USA that collaborates and shares best practices with Coventry University. This team looks to build on this case study with future research to share with peer institutions.

Bloom, B., Englehart, M.,Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive domain.* New York: Longmans, Green.

Burgett, J.M. (2016). Leveraging Immersion Technologies in Construction Management Education: A National Electrical Code 3D Simulation Tool. *ASC Proceedings of the 52nd. International Conference,* Provo, UT. April 2016

Park, M., Chan S.L., & Ingawale-Verma, Y. (2003). Three Success Factors for Simulation Based Construction Education. *Associated Schools of Construction Journal of Construction Education,* Summer 2003, Vol. 8, No.2 pp. 101-114

Rokooei, S., Goedert, J., & Woldesenbet, A. (2017). Investigating Students' Perception Using Construction Management Simulations. *ASC Proceedings of the 53rd. International Conference,* Seattle, WA. April 2017

Sawhney, A., Mund, A., & Koczenasz, J. (2001). Internet-Based Interactive Construction Management Learning System. *Associated Schools of Construction Journal of Construction Education,* Fall 2001, Vol. 6 No.3 pp. 124-138