Developing Undergraduate Construction Management Students' Abilities to Manage Projects Through a Computer-Based Simulation

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ABSTRACT

Construction management is a relatively young profession with a curriculum that is continually evolving. The multiple accreditations that are sought by universities in Australia mean that curricula are frequently overcrowded and financial management is a subject that is challenging to deliver. This paper describes the approach adopted at one university where final year students' knowledge, skills and abilities about financial management are developed by simulating the operations of a hypothetical construction company. The paper describes the way it is delivered and the challenges experienced over the years.

Keywords: Financial management, construction industry, simulation

CONTEXT

The discipline of construction management has evolved in response to changes in the ways construction projects are procured, designed and constructed. The traditional role of architects as leaders of construction teams has changed, with other professionals taking overall responsibility for steering projects to completion. Before the introduction of construction management degrees, the professionals who managed construction projects were predominantly drawn from the architecture and civil engineering disciplines. Several factors have driven the development of degree programs that target the management of construction processes. These include shortages of architects and civil engineers who specialise in managing construction projects, and a lack of focus in architecture and civil engineering degree programs on management-related topics (such as finance and accounting, economics, management principles and construction law). Construction management degree programs have evolved to meet this need. Construction management curricula are designed to enable graduates to manage the multitude of operations involved in procuring, designing, constructing, commissioning, maintaining and eventually deconstructing modern buildings.

One of the challenges facing those developing construction management curricula is which subjects to include. Construction managers have much in common with the disciplines of architecture and civil engineering, but focus on different aspects. For example, engineers need to be able to predict the forces that a structure needs to accommodate and for ensuring that structural members are adequately sized. By way of contrast, construction managers are not responsible for establishing the size of structural members. They are, however, expected to maintain safe working conditions on site. As such they need an appreciation of structural theory so that they would know, for example, where to expect to find reinforcement in a reinforced concrete beam. They need to be able to identify when reinforcement is incorrectly positioned or missing, rather than the size and number of steel bars required. These nuances present academics with dilemmas when trying to rationalise the curricula to be taught to students from multiple disciplines.

In many Commonwealth countries the development of these curricula are informed by the requirements of the various professional institutes that accredit these degrees. A particular challenge facing those developing these curricula in Australia is the number of professional institutes that accreditation is sought from. Relevant institutes include the Australian Institute of Building (AIB, 2004), the Australian Institute of Quantity Surveying (AIQS, 2008), the Royal Institute of Chartered Surveyors (RICS, 2008) and the Chartered Institute of Building (CIOB, 2008). Most construction management programs are accredited by more than one institute, and some are accredited by more than ten (Sher, 2012). It is understandable then, that most academics in this discipline consider their curriculum to be overcrowded and, in some cases, fragmented (Williams, Sher, & Simmons, 2010).

This paper describes how students enrolled in the Bachelor of Construction Management (BCM) degree in the School of Architecture and Built Environment at the University of Newcastle, Australia learn about the financial management of construction companies. It starts with by providing brief background to the BCM degree, and the

rationale and architecture of the course, a description of the way in which it is delivered, followed by student evaluation and observations for future developments.

BACKGROUND

The University of Newcastle is the largest regional university in Australia, with a student population of over 37 000. Over 85 undergraduate programs are available across five faculties. The BCM degree is offered in the School of Architecture and Built Environment (one of three Schools within the Faculty of Engineering and Built Environment). The first cohort of BCM students graduated in 1994. The degree continues to be delivered based on problem-based learning principles, having drawn on the University's medical faculty's early engagement with this approach. It is offered to on-campus as well as to distance-learning students. Starting with a modest an intake of 17 students, the program has grown considerably with over 600 students enrolled in 2013. Class sizes vary from approximately 80 to over 300 (where courses are delivered to the architecture discipline and as general electives).

In line with the increased capacity of the Internet to support teaching and learning, the BCM program has embraced digital methods of delivery. Use of paper-based course materials for distance learners ceased in 2006. Courses are delivered in blended-mode with face-to-face activities being recorded using a variety of approaches and made available to on-campus and distance learners alike.

BCM students are recruited from a wide range of backgrounds. Some are school leavers, whilst others are of mature age and working in industry. In line with many higher degree students in other disciplines and countries (Curtis & Williams, 2002), many BCM students work part-time.

The BCM is a four year embedded Honours program. The early years of the program focus on technology-related topics, equipping students for the management-related challenges they experience during the latter courses (The University of Newcastle, 2013a). The course described in this paper is taken during the final year of students' studies and is described below. It targets the development of their knowledge of, skills in and attitudes about the financial management of construction companies.

It is relevant to note that the construction industry in Australia is plagued by insolvencies. Heaton (2013) highlights this, noting that "in 2010/11 alone, an analysis of data from the Australian Securities and Investments Commission… reveals that no fewer than 1,862 construction firms went into insolvency, accounting for a whopping 23 per cent of all insolvencies throughout Australia." Responding to the recent Collins inquiry into insolvency, the New South Wales Government has recommended (NSW Government Finance and Services, 2013, Recommendation 43) that industry works to develop the financial and management skills of construction personnel. The course described below illustrates one of the ways this need is being addressed.

COURSE CONTENT

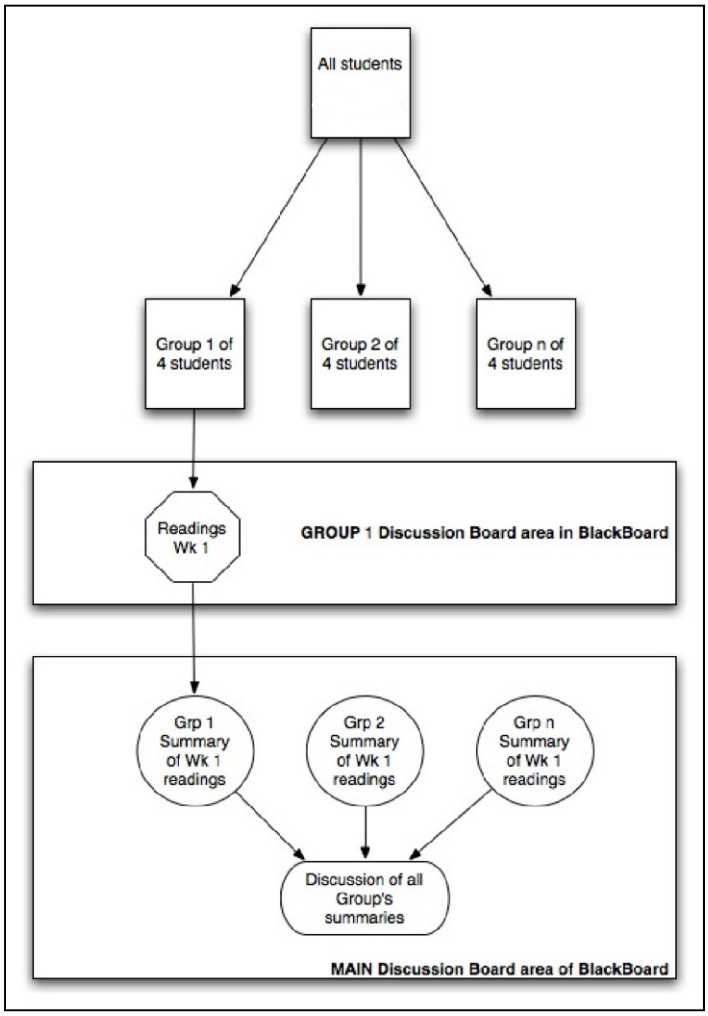
Whilst construction managers are not expected to be accountants, they are expected to be able to make informed decisions about the financial management of construction companies. This course introduces students to the principles of financial management and then requires them to apply what they have learned by simulating the running of a construction company. Students take on the management of a hypothetical construction company and are required to trade for a period of two years using a computer-based simulation package. The learning outcomes of the course relevant to this paper are set out in Table 1.

Table 1: Learning outcomes

On successful completion of this course, you will be able to:
• apply the principles underpinning the financial management of construction companies. • develop and appraise strategic management plans for construction companies. • simulate the management of a construction companies. • develop effective communication skills related to working in teams in virtual environments. • justify the strengths and weaknesses of your learning experiences about managing construction companies

Students are introduced to the principles of financial management through a textbook (Peterson, 2013). They allocate themselves into groups, and then review and discuss selected chapters with their peers on a weekly basis. The chapters are supplemented with additional readings, sourced from newspapers, trade journals and podcasts (e.g. Factoring.org.uk, 2013). Collectively these emphasize the contemporary nature and importance of the subject matter. Students read the materials and then enter into discussions with their peers via a group discussion board on our Blackboard learning management system (Figure 1). They are expected to enter into dialogue with their peers, respond to the observations of others, relate topics to their own work-experience (if any), and support their statements with additional resources. At the end of a week, one member of each group is required to compile a summary of the group's efforts and post this on a discussion board accessible to the whole class (Figure 1). All students are required to review some of the summaries and offer comments of their own. Each student's postings are assessed using a rubric that rewards their engagement with their peers, evidence of familiarity with the readings, their style of communication and evidence of further research.

Figure 1: Administration of weekly readings

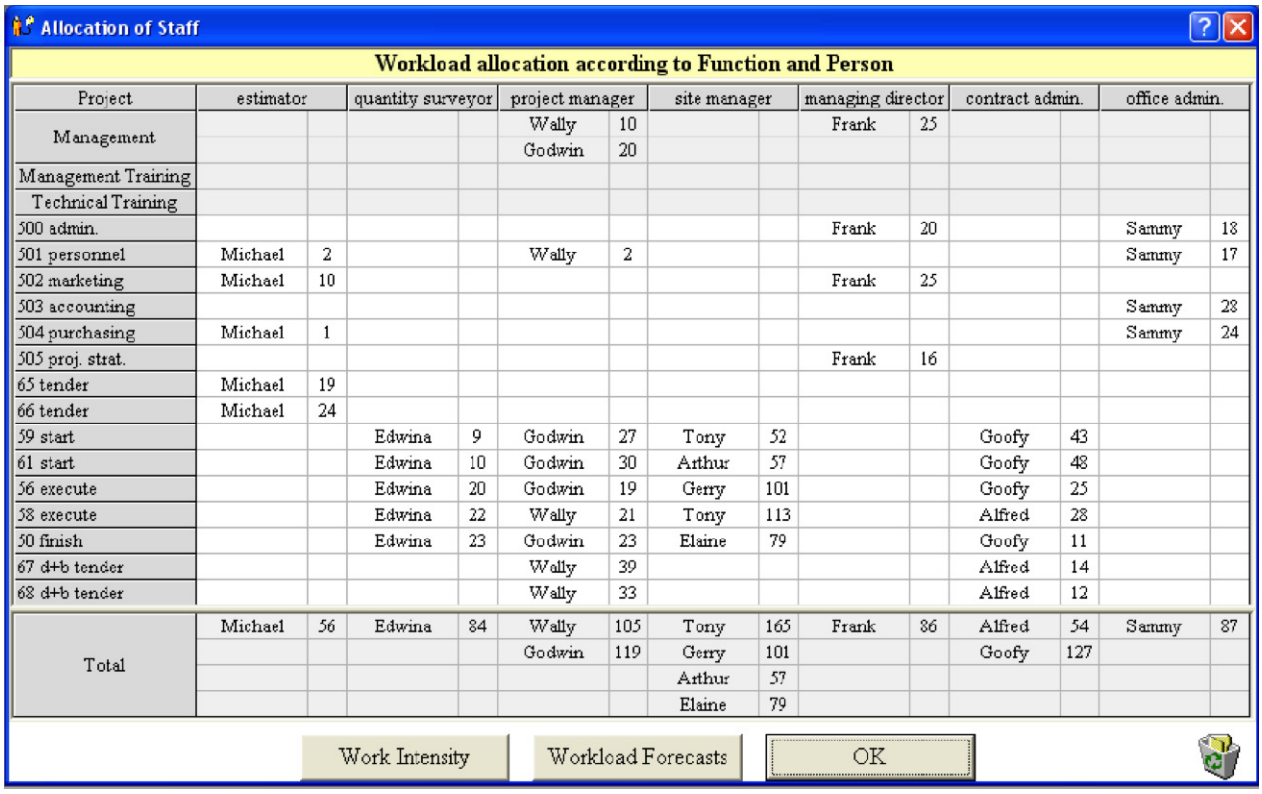


On completion of the readings, students complete a summative on-line assessment before embarking on their next assignment, a computer simulation. AROUSAL (Lansley, Irwig, Hipwell, & Fitsakis, 2013), the package they use, allows them to simulate the running of a small to medium sized construction company. AROUSAL was developed in the 1980's at the University of Reading, UK, and has been refined and augmented over the years. A dataset specific to Australia has been developed based on a company operating on the outskirts of Melbourne. Students trade for a simulated period of two years by making decisions on a quarterly basis and are assessed on the financial performance of their company.

Students start by reviewing the historical data contained in the package. AROUSAL provides data about the size of projects the company has undertaken in the past, the types of construction projects that have been completed, the methods of construction involved, the location of these projects as well as indicators of market demand at the time. They are also provided with data about the existing management structure of their company and the staff it employs. Students are required to work in groups to consider these data and develop a strategic plan for their company for the next two simulated years of trading. Their plan is assessed in accordance with the follow criteria: analysis of historical data, feasibility of their strategic plan, depth and justification of their financial plan, depth and justification of their staffing plan as well as their communication style.

Students then work individually to put their strategic plans into practice through the simulation application. AROUSAL allows them to review the existing commitments of their workforce and bid for new projects. Should they wish to bid for a particular project, they do so by entering a mark-up they feel will win the job. Where necessary, students can recruit new staff by reviewing the résumés of applicants available at the time. Students are also able to terminate the employment of staff they no longer require, target specific geographic locations for future work, reallocate the responsibilities of their staff and so on. They are provided with an overview of the aggregated workload of the staff of their company (Figure 2) which enables them to identify the capacity of individuals to take on extra work (In Figure 2, 100 represents a full workload).

Figure 2: Workload allocation



Project	estimator		quantity surveyor		project manager		site manager		managing director		contract admin.		office admin.	
Management					Wally	10			Frank	25				
					Godwin	20								
Management Training														
Technical Training														
500 admin.									Frank	20			Sammy	18
501 personnel	Michael	2			Wally	2							Sammy	17
502 marketing	Michael	10							Frank	25				
503 accounting													Sammy	28
504 purchasing	Michael	1											Sammy	24
505 proj. strat.									Frank	16				
65 tender	Michael	19												
66 tender	Michael	24												
59 start			Edwina	9	Godwin	27	Tony	52			Goofy	43		
61 start			Edwina	10	Godwin	30	Arthur	57			Goofy	48		
56 execute			Edwina	20	Godwin	19	Gerry	101			Goofy	25		
58 execute			Edwina	22	Wally	21	Tony	113			Alfred	28		
50 finish			Edwina	23	Godwin	23	Elaine	79			Goofy	11		
67 d+b tender					Wally	39					Alfred	14		
68 d+b tender					Wally	33					Alfred	12		
Total	Michael	56	Edwina	84	Wally	105	Tony	165	Frank	86	Alfred	54	Sammy	87
					Godwin	119	Gerry	101			Goofy	127		
							Arthur	57						
							Elaine	79						

After each simulation, AROUSAL generates reports that show, inter alia, progress, cashflow analyses, financial data, staff allocation and issues, and problem activities. Students are required to evaluate the financial health of their company by calculating five financial ratios (net worth, net cashflow, gross profit margin, current ratio, and debtors collection period vs. creditors payment period). These ratios provide the basis on which this part of the course is assessed. Students' ratios are ranked in turn and a score is attached to each ranking. A value of one is given to the strongest ratio with successive rankings attracting progressively higher numbers. When each ratio has been ranked and scored, the scores are totalled, and the lowest score is awarded 100%. Marks are apportioned to the remaining students on the basis of their accumulated score, with 50% being awarded to the student whose results were worst but which represented a serious attempt at running the simulation.

REFLECTIVE PRACTICE

Most students take the simulations seriously as their results are assessed. Pleasingly, they generally find running the simulations to be an engaging experience. Students rated their overall satisfaction with the quality of the course at 4.0 (out of 5) and the challenge the course provided at 4.25 (out of 5) (The University of Newcastle, 2013b). Whilst it is possible that the competitive manner in which the simulations were organised contributes to their satisfaction, it was pleasing to note that some students continued the simulation for several additional years. Their motivation was to see what would increase the health of their company. This underscores the strengths of simulation as a teaching and learning strategy. Running a profitable business is not intuitive. There are a multitude of inter-related factors that need to be considered when making decisions, and these are not immediately apparent. For example, some students do not appreciate the significance of receiving payments from their clients in a timely manner. The imaginary company the students inherit employs a part-time bookkeeper. Whilst this arrangement is initially satisfactory, the bookkeeper does not have the capacity or the background to cope when the company grows. Few students employ staff with accountancy skills to address this shortcoming. Another example is where students win projects that are a considerable distance from their imaginary home base. In such circumstances there are advantages to employing local sub-contractors. The simulation allows students to decide how much work to sub-let but few students make connections between geographic location and the complaints of their workforce when working away from home.

The reality is that students are expected to make mistakes and to learn from these mistakes. Indeed, allowing students to experience real-world challenges without real-world consequences is a prime outcome of simulation exercises (Harder, 2010). To capitalise of these opportunities, students are required to prepare a reflective report and to relate their experiences of the simulations to the theory they engaged with at the start of the course. These reflective reports are assessed in accordance with the following criteria: description of their simulations, explanation and interpretation of their simulation results, use of additional resources to supplement the aforementioned explanations and communication style.

CHALLENGES

One of the difficulties we have experienced over the years is that of poor attendance by on-campus students at face-to-face lectures. It may be appealing to link such poor attendance with the provision of on-line lectures, but studies like those of Larkin (2010) indicate that students' motivations are more complex. Given opportunities to manage their own time, students value autonomy (Drennan, Kennedy, & Pisarski, 2005) and this may contribute to some electing to engage in other activities rather than attend lectures. Partly as a pragmatic response to the reality of poor attendance, the course is delivered entirely as distance learning.

The subject matter of this course lends itself to group work. However, facilitating group work is generally problematic (Aman et al., 2007; Graham & Crawley, 2010; Sher & Williams, 2007). Students frequently express concerns about the diligence of their peers (Hardie, 2007) and in this case, these were exacerbated by the demographic profile of the students. Approximately half were mature-age distance learners, many of whom were in full-time employment. The remainder were mainly school-leavers with minimal work experience. Attempts to harness the experience of the mature-age distance learners were compromised by the work pressures they need to cope with. These may have discouraged some of them from being supportive of their younger peers. Furthermore, the temporal priorities of distance learners rarely aligned with those of the on-campus students. Whilst many on-campus students wished to work on their group assignments during the day, distance learners generally preferred working after-hours and on weekends. Synchronous meetings were thus difficult to arrange, and this compounded the difficulties students experienced when working together.

Students were able to download and use their own version of the software. This is convenient when they work independently but problematic when students work in groups (as each group member needs to make identical decisions to receive the same results as their colleagues). As a consequence, and in addition to the challenges of facilitating group work involving distance learning and on-campus students, use of groups has been restricted to reviewing the historical data provided with AROUSAL (as described above).

CONCLUDING COMMENTS

An understanding of financial management is essential for those managing construction projects and organisations. However, the crowded nature of many undergraduate construction management curricula in Australia makes it difficult for finance and management subjects to be delivered using traditional approaches. Furthermore, the trend in many Commonwealth countries for students to work whilst studying appears set to continue for the foreseeable future. Finding novel and effective ways of meeting the diverse needs and requirements of students is one of the challenges facing university construction management educators. Simulations are effective in exposing students to real-life situations and of engaging their interest (Beckem & Watkins, 2012). For example, virtual reality is being trialled as a means of simulating the day-to-day issues construction managers are likely to face on site (Austin & Soetanto, 2010). Simulations provide safe environments in which students and wider communities can operate. For example, nursing students practice their clinical skills using mannequins before they are allowed to treat real patients (Harder, 2010). Community members need to be similarly protected from the actions of novice construction managers. Giving students stewardship of the management of commercial construction organisations is neither desirable nor possible.

In summary, simulations address many of the challenges facing university educators trying to engage their students. They provide students "with valuable experiential learning opportunities that are easily scalable, reusable, and uniquely suited to enable instructors to assess students while simultaneously providing them with authentic student-centered learning journeys that increase student engagement." (Beckem & Watkins, 2012, p. 61)

However, simulations can be challenging to organise and facilitate. We were fortunate to be able to arrange for a UK simulation package to be adapted to our local conditions. Locating suitable simulation applications is therefore one of the difficulties facing educators. Other challenges include familiarising staff with the chosen simulation applications and devising ways for students' efforts to be assessed. Notwithstanding these challenges, simulations provide effective approaches that can be harnessed to meet the requirements of current cohorts of university students.

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