



EXPERIENCE IN THE DELIVERY OF AN ENGINEERING CAPSTONE DESIGN COURSE FOR ASSOCIATE DEGREE PROGRAM AT THE UNIVERSITY OF SOUTHERN QUEENSLAND

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Abstract

The objective of this paper is to describe the delivery of the engineering technology level capstone design course at the University of Southern Queensland (USQ) where on-campus students had a chance to effectively engage with external students in a blended mode of delivery. The resources supplied from online sources, together with a well-designed assessment criterion of this course, helped to engage students in effective participation. The experiences in delivery gained when offering this AD capstone project in 2015 were used as scenarios to highlight the pros and cons of this blended mode of delivery.

The results from selected projects show that these projects helped students to enhance their ability to optimise construction tasks including: proposing cost effective labour materials, designing and constructing reinforced concrete and masonry structure and comparing the probable output from using unit cost and productivity estimations. In addition, students have also used their enhanced design knowledge and drafting techniques learned from this degree program to professionally complete the project. However, maintaining the spirit of teams and continuous communication and access to data resources were identified to be challenging for students in this course. Alternatively, this blended learning model has positively influenced to increasing learning outcomes by helping students in various ways to undertake wide-ranging tasks. In particular, less experienced students have been able to expand their skill-set, knowledge and competencies from working alongside experienced students who are already working for the industry. This paper would be useful for academics considering a similar course with blended interaction.

Keywords: Capstone Project, Blended Course Management, Team Project

1. Introduction

Typical Civil Engineering related projects require considerable input from Civil Engineers, where they use their competencies to execute several roles, including project manager, site engineer, engineering supervisor, technologist and technician., Traditionally the vocational education and training (VET) qualification plays a vital role in educating experts for the last three engineering roles. The Technical and Further Education (TAFE) institutes, as well as privately registered training organisations (RTO) institutions, have been playing a vital role as key educational providers in Australia (Dowling, 2010), but over the last two decades several universities have also started offering a similar level of programs.

Currently, the Australian Qualification Framework (AQF) is the national policy for regulated qualifications in the Australian education and training system. The AQF recognises Advanced Diplomas offered by VET sectors, as well as the Associate Degrees offered by the Universities as Level 6 qualification under its framework (AQF, 2013). In addition, Engineers

Australia (EA) has its professional accreditation routes to assess and hence assure the quality of these programs.

The University of Southern Queensland (USQ) has a reputation as one of Australia's leading providers of the blended mode of education programs. Over the last two decades, USQ has offered an Associate Degree in Civil Engineering (AD-CEng) for students in two modes: on-campus and online, where around 75% of the students online are those who work fulltime while studying. This degree program is well designed and the delivery of the courses is divided into two bands: core courses and practices courses. These courses are very well built around a sound curriculum to compliment the EA's accreditation requirement. Upon graduation, the USQ degree holders can apply for membership to become an Engineering Associate (Officer) and, with experience, they can even apply for chartered status as an Engineering Officer.

Since 2011, in order to improve the skills, knowledge and competencies of the graduates, a capstone project course namely ENG2911–AD Capstone project was introduced to the students enrolled in the program. This course aimed to expose students to practical civil engineering design problems, including: use of design codes, standards and guidelines; drafting, material and manpower estimations; costing and project scheduling. At USQ, the students in this course are put into to a team where on campus and online students work together in a blended learning environment to complete course requirements. This paper highlights the important aspects covered and challenges faced by the students within the blended mode of delivery.

2. Course objectives

The Associate Degree program consists of 16 core courses and 6 practices courses and the AD Capstone project is one of its practice courses. This course was designed for students to complete during their last semester of study or after successful completion of a minimum of 12 courses in the program. As per the study schedule within this degree, this course is currently offered in Semester 2 (July to November) annually. The course objectives define the student learning outcomes for a course, and on completion of this course, students should be able to:

- contribute as part of a team to complete a selected project within a specified time utilizing recognized Australian codes and standards;
- demonstrate a sound knowledge of basic engineering principles within a branch of engineering practice at an engineering associate level, and also demonstrate the ability to apply them to normally-encountered situations;
- using a systems approach, deconstruct the project into its components and design an engineering solution in accordance with established practices and precedents; and
- communicate project plans, progress and outcomes through written and oral mediums.

3. Course assessment

The assessment items of this course consist of a group written report (70%) and an individual diary (30%), and these items were required to be uploaded to the StudyDesk by the end of 15th week of the semester as detailed in Figure 1. The purpose of this written report is to communicate to stakeholders the design solution developed by the project team. The overall evaluation is divided into three main categories: project planning, project execution, and project communication. Similarly, the individual diary will give students the opportunity to demonstrate their individual contribution to the project. It will also allow students to practice writing a Career Episode Report required by Engineers Australia (EA) for assessment of Stage 1 competencies. The written report and individual diaries will be assessed by faculty experts to finalise the grades. Since this is a practical course, after the final assessment a grade of Pass/Fail will be given for each student.

3.1 Course materials and guidance

The on-campus and online students can enrol to this course. In 2015, there were 29 civil engineering students enrolled in this course from four different states in Australia: 18 students from Queensland (QLD), 8 from New South Wales (NSW), 2 from Western Australia (WA) and 1 from Victoria (VIC), where three of them were on-campus students.

At USQ, an online resource platform, called 'StudyDesk', is designed on the Moodle environment and it acts as an important space where students enrolled in a course can effectively participate in their learning. Study materials and required instructions are uploaded to the course StudyDesk, where various forums can also be created within it to support student interaction. This StudyDesk can be used to deliver timely instructions to the students enrolled despite their status (on-campus or on-line). At the beginning of the semester, a study schedule, a list of sample projects with the necessary components, assignment schedules and assessment criteria are all uploaded to the course StudyDesk.

3.2 Project identification

Initially, as per the examiner's guidance, students introduced themselves and their project interests to peers and formed a group based on their interest to a tentative civil engineering project. During the first week of this course, the students familiarised themselves with fellow students and also expressed their interest towards a suitable project area (e.g., Rehabilitation of Timber Bridge). In 2015, a group of five students interested in a timber bridge rehabilitation named themselves 'BridgeBandits'. This dialog continued until all the students formed their **group based on a tentative selection of a Civil Engineering project**. Finally, each group will be officially confirmed by the examiner upon a request from their presentative leader of the group. After the group forms, a separate space on StudyDesk will be allocated for each group to discuss with their group members where students outside the group cannot access their posts. This forum will be open throughout the semester so that the members of the group can discuss, share their enthusiasm, problems, solutions and exchange their resources. It was found that the students accessed and returned to their course StudyDesk in their own time.

Usually, developing the realistic project is time-consuming for students; therefore, the academics developed and uploaded a few tentative project proposals on the course StudyDesk to act as guides. Students were given a chance to modify the uploaded project to suite their local conditions or propose their own or professionally originated project topics.

A focused project should require students to apply discipline-specific skills and knowledge acquired during their study program (including the use of design standards and guidelines) and these required elements were also communicated to the students via the course StudyDesk. The formation of a suitable design project often require students to hold a face-to-face meeting; however the locations of external students did not allow them to meet personally. Therefore, the individual group identified their suitable method for group communication as soon as their group is finalised. Generally, students agreed to use social media like Skype or Zoom to hold frequent meetings. These interactions start within the first two weeks of the semester, and with the fullest engagement of group members a group is expected to propose a suitable project topic (e.g., Upgrading Timber Bridge crossing Dunbible Creek in Queensland) by the end of week 3.

For example, in Semester 2, 2015, there were 5 AD projects carried out by a total of 5 groups (29 students), and the followings are the focused project topics that were under taken by each group:

- Group 1: Upgrading Timber Bridge crossing Dunbible Creek in Queensland
- Group 2: Expansion of Plutonic Aerodrome Runway, Queensland
- Group 3: Road geometry realignment to intersection at Derribong and Algalah Streets in New South Wales (NSW)

- Group 4: Redesign the substandard intersection of Mid-Western Highway and Hobby's Yards Road at Blayney, NSW
- Group 5: Rehabilitation of Kirwans Bridge at Nagambie, Melbourne.

3.3 Detail planning and execution

Project components and responsibilities

The course requirements, the scope of the project and assessment criteria help to identify appropriate technical components to dedicate the work to the individual members. For example, in the bridge rehabilitation project, the following technical components were decided in 2015: 'Bridge identification, site investigation', 'Reporting of defects and other technical information', 'Researching list of design standards, collecting background information, design and drafting', 'Design of road pavement, material identification and placing of roadside furniture', 'Identification of suitable material, manpower estimation and cost valuation and preparation of BOQ', and 'Preparation of a construction plan integrating sustainability'. With this in scope, the actual duties within the project described by the 'Bridge Bandits' includes:

- The investigation into Creek Bridge including background information, identification of specific needs of users, community/stakeholder consideration and impacts from future growth
- Develop an understanding of standards and regulations involved in bridge design
- Assess the advantages and disadvantages of replacement/rehabilitation options
- Finalise design providing a two-lane bridge with a higher tonnage limit with a 40-year lifespan
- Itemising and scheduling construct works according to risk management and safety principles with minimal social, economic and environmental impacts.

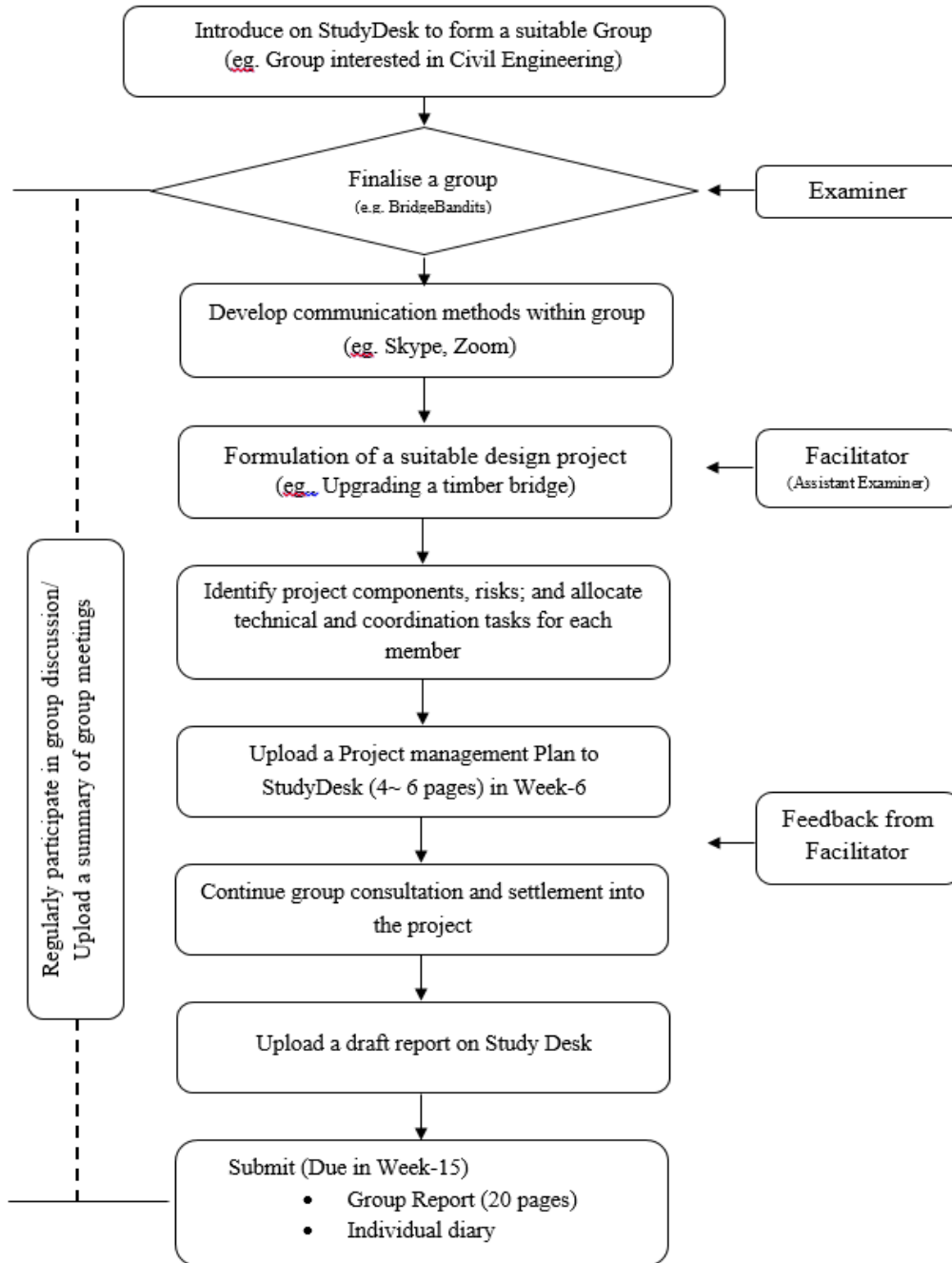


Figure 1: Activities on flow chart for AD capstone project

Similarly, after finalising their research topic, each group forwarded their project proposal to the relevant academic member to get his approval. The proposal contained the following: title, the overall problem/objective, a breakdown of the tasks/goals required to solve the problem, the skills required to address those goals, project deliverables/benchmarks (milestones) and resources required to produce the conceptual design. The maximum page limit for this **project proposal was around 2 pages**. A typical project proposal will contain the following: the overall problem and project objective, a breakdown of the tasks/goals required to solve the problem, the skills required to address those goals, project deliverables/benchmarks or milestones and resources required to produce the conceptual design. After receiving the project proposal, the academic facilitator provided the group with feedback for their proposal where academics will consider the project suitability. The

following issues will be checked when finalising the applicability of a project: inclusion of design components within Australian standards required to complete the design, inclusion of ample elements to divide among the team members, completion of tasks within a reasonable timeline to ensure timely deliverables, the availability of required resources or data sources, and the achievability of the project within the time allocated for the course. Final approval for topics was made by the Assistant examiner in consultation with relevant faculty staff, if required.

This is a conceptual design project so students are advised not to focus on the small details, but keep information broad, clear and concise. At the end of the third week, each group was expected to establish a regular contact time and communication method for their team, determine any Australian Standards that may need researching for the project and decide technical and non-technical tasks and assign them for individual members to research and complete.

3.4 Allocating technical tasks

Each team member of a group supplied their background, knowledge and expertise at the beginning of the project. Technical tasks within the project were allocated based on their information. It must be mentioned that about 75% of USQ's students study while they are working and that it was found that a team member's current employment position and individual strengths and weaknesses played a vital role in deciding these tasks. For example, a few members were involved in project management, progress reporting, general research, drafting and collecting background information. Other members were heavily involved in the design (including researching lists of applicable standards) guidelines and structural and material selection. Therefore, expertise from an experienced member in a particular area can be fruitful for the project components as per the detailed given above under the project components.

3.5 Allocation of coordination tasks

Various roles were identified by individual groups to manage the coordination tasks within the project. For example, Group 1 (BridgeBantits) divided its non-technical tasks as Team Leader, Editor, Document Coordinator, Minutes taker, Meeting Chair, Agenda writer and Miscellaneous challenge where the responsibilities for each role varied. The team Leader was responsible for making sure everyone knew their responsibilities and deadlines and ensured that tasks were completed on time to an appropriate standard. The team leader was to also oversee the minutes and current week information to ensure ongoing progress. The editor created a template for the team report, updated and modified the team report as parts are completed, and was responsible for the final proof-read and edit of the report before submission. The role of the document coordinator was to form the Google Document, monitor all information posted to it or to the StudyDesk forum, take responsibility for making sure it is kept tidy and that information/research is easy to find for all group members. The minute taker recorded Skype or Zoom meetings and wrote up minutes on the Google Document template. The meeting Chair and agenda writer created an agenda for the next meeting and posted on Google Documents at least one day before the meeting so people can add additional topics if required. This person also chaired the meeting and made sure everyone sticks to the agenda. The Minutes taker was expected to have the minutes completed within approximately 24 hours of the meeting. The person allocated the 'miscellaneous challenge' helps all other members within the group to ensure the project is achieving goals and is allocated miscellaneous tasks that don't fit under the above categories. However, the last three roles were rotated approximately every 3 weeks to allow for varied workloads in considerations of the other duties. Tasks are split up weekly into manageable portions in order to ensure equal contribution, but continue to maintain a steady pace. The information such as minutes, agenda and others as appropriate were also on the StudyDesk forum to monitor the group progress by academics.

3.6 Development of a project management plan

At the end of the 5th week, each group developed a 'Project Management Plan' outlining the following: project scope, project team, stakeholders, applicable standards, project risks, project milestones and schedule (Gantt chart, network milestone chart, tables or other data representations were be used), design tools to be used in the project, communication schedule, the responsibilities and roles of team members form task allocation, design and report review procedure.

The failure or success of the project relies heavily on its management technique and specifically relates to identifying, assessing, controlling and reviewing risks. Therefore, it is one of the key components in a Project management plan. Each team was expected to make their best effort to identify potential risks early on before things get out of hand. This is brought up briefly for discussion every meeting by students. The maximum page limit for this 'Project Management Plan' is 5 pages, and it was to be attached with the final report as one of its Appendixes.

3.7 Challenges in execution

Information gathering, ability to use Engineering principles to design and construction of structural elements, developing a suitable construction approach in accordance with established practices and precedents and compliance with other project requirements are important in project execution. When targeting to carry out a project of this nature as a group, it was recognised that team participation and communication and accessibility to reliable data was critical for successful completion.

3.8 Team participation and communication

In this course, the students initially showed a keen interest to join a group for the formulation of project topics. Mostly, the students' contribution until the development of the 'Project Management Plan' (around the end of week 5) was good, as to date there have been no serious concerns with conflict amongst team members in this time period. It was seen that, after the submission of the 'Project Management Plan', students were finding it hard to regain momentum, grasp concepts and balance this project with their other professional and academic commitments. At this stage, motivation was the essential component that encouraged students; so various tasks created and allocated for each individual in the team to remain focused and driven.

During each meeting, a designated colleague presents a statement of the work he completed in his role. A form with a summary document, drawings, methods used for calculations, standards and guidelines used are made available for the group members via the StudyDesk forum. In order to exchange the working files between group members, in addition to the space on StudyDesk, other resources such as Google Documents and Dropbox were used effectively. Communication was kept open and members were encouraged to speak up with difficulties or questions. Roles such as team leader and chairperson also encouraged collective communication between members. Subgroups are created in later stages to divide up the workload and allow for better communication.

Despite all of these efforts, members of the team were all individuals; each with a busy lifestyle and various other subjects and work commitments. Therefore, many groups found it difficult to schedule a time period where all group members were able to meet. It was also noticed that participation to the project via online mode can be stressful and emotional for some students and the challenges ranged from feeling isolated to being unsure what to do and not receiving learning support. For example, a group had to work harder than others in early stages to eliminate some of the challenges of hosting the files and identifying a suitable way to serve them up to the students on different platforms. Furthermore, experienced students spent extra time to facilitate less experienced students. However, a group soon

formulated effective ways to communicate properly where access to minutes of the meetings, sending group emails and a well pre-planned schedule remain in place as effective mediums to guide the group students.

At the completion of a project, a group identifies the following as risks associated with group work: competent individuals within a team may not function well together as a team; some individuals may cause delays in meeting course requirements for deadlines, team submissions, non-attendance to meetings; unfair workloads may be placed on members of the team due to negligence of others; the team environment and culture may be affected by individuals not contributing fairly to the team; differing aspirations in achievement could emotional issues to team members and career or academic setbacks could be caused if team objectives are not reached.

4.Data collection

Students collected reasonable data for their study from their designated site visit or site investigation; if deemed necessary, they have discussions with the stakeholders as well. However, most of the groups struggled to collect additional technical data from the secondary data sources for their design and analysis. Due to lack of available data or trustable data source, it has been challenging for the group to come up with a cost effective solution. For example, when estimating costs for a timber bridge rehabilitation project, the students made contact with the industry partners to get necessary input for their project (e.g., market rates, required resources and manpower and machinery requirements to develop time-schedule). However, due to the competitiveness within the construction industry students were unable to collect the data to fulfil all of their data goals.

4.1 Results

Outcomes from individual projects were promising and each projects' execution covered a broader range of findings that can directly be applicable to similar realistic projects. In this section, a list of top three findings was highlighted, together with their project scope.

Group 1: Upgrading Timber Bridge crossing Dunbible Creek in Queensland targeted to redesign the existing bridge to satisfy the need of the community for a design life of 40 years. The primary data was collected from site investigation and consultation with the stakeholders. The report has given key emphasis to the following: risk management while construction, reduced environment effects and use of local materials in construction.

Group 2: The design for the runway extension at the Plutonic Aerodrome is a 600m linear extension (as far as practical) to the existing horizontal and vertical alignments of the runway. Students in this group demonstrate their utmost ability in the following areas: proficiency in using standards for runway design, earthwork computation, and proposing cost-effective construction methods.

Group 3: Road geometry realignment at the intersection of Derribong and Algalah Streets in New South Wales (NSW) is necessary to improve road safety and driving comfort. The notable outcomes of this realignment project include: proficiency in the design and drafting of road infrastructure using electronic equipment and associated software packages, state development of related construction and proposed drainage arrangement for relocating public utilities.

Group 4: The proposed innovative concept design addresses the issues of the identified substandard intersection on the Mid-Western Highway and Hobby's Yards Road at Blayney. The new design complies with Austroads and Australian standards and has been designed for 50km/h speed limit. An in-depth assessment was made to identify the environmental, property and drainage impacts. The group also included an evaluation of impacts on existing utilities to provide an intensive concept design to be further developed construction detail

and an evaluation of the use of topographic surveys to collect the existing road profile. These evaluations were some of the most notable achievements of this group.

Group 5: Rehabilitation of Kirwans Bridge at Nagambie, Melbourne. The site investigation by the students from NSW was properly communicated to others elsewhere. The use of established practices in excavation, hauling and embankment construction, selection of plant and meachinaries, as well as the optimisation in materials usage was notable outcomes from this project.

5. Students' feedback

Upon completion of the project, a survey was sent to the students and about 35% of the students who undertook this course in 2015 responded to the survey. The overall rating was significantly higher than for other courses of the Associate Degree in Civil Engineering program. Although many students appreciated the conduct of this course, the general statements given by the online students indicated that this capstone project is not the best course in their program because almost all of them are already working with similar responsibilities and they are directly using their knowledge to support engineering design in a practice area (these skills include use of codes, standards, empirical information and data reused from past designs).Therefore, they feel that they have adequate competencies to perform a task skilfully in complex and undefined situations. Thus, employment history becomes a critical and noteworthy parameter in the rating of this course.

Conclusion

An AD capstone project increases students' competencies (given that they do not already work in this area) which introduces them to perform professional works in an unexpected and real world situation. The blended learning environment at USQ has also been employed to deliver this course where on campus and online students participate effectively. Four important phases of this course, namely: initialisation and group formation; project identification, detail planning and execution, and typical results were documented, and examples form5 realistic AD capstone projects offered involving 29 students were used to highlight the important outcomes. Although no limitation was initially placed on the students' creativity to a said project, the following factors such as time limitation, resource and cost considerations, availability of data source, stakeholders' acceptance and other relevant constraints were factors to be considered critically to place pressure on groups when selecting suitable project.

The assessment scheme of this project course helped students to successfully complete the project starting from group formation to completion of the project and this helped the students to gain a strong foundation on the course objectives. In this effective blended learning environment, in addition to the course StudyDesk space, the effective use of communication flat forms such as Skype and Zoom and file exchanging mediums such as Google Document and Dropbox were effectively used by students. Individual groups used these median to maintain their enthusiasm and solve their problems, solutions and online resources in isolation from each other group members.

This study on learning and teaching process can guide an academic considering to conduct similar courses starting from developing study material, resource planning, taking control of challenges, linking to appropriate pedagogy and assessment methods.

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