Learning and Teaching of Capstone Final Year Engineering Projects: An Australian Study

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The learning and teaching methodology of the capstone final year engineering project (FYEP) as employed in Australia is presented and discussed in this paper. A questionnaire was conducted to answer a broad research question: *What is the current approach used in learning and teaching of capstone FYEPs*? The questionnaire outcomes and a number of common issues, discrepancies and inconsistencies found are outlined in the paper. The study indicates the need to engage in further dialogue with supervisors, professors and students to develop best practice in the FYEP paradigm.

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Introduction

Accreditation requirements for undergraduate programs for professional engineers require final year students to complete capstone projects. The FYEP is a significant part of work that involves creative activity and original thinking. A good engineering project has students start with the formulation of a problem, suggest alternative solutions, and then implement one of them. Generally, students can achieve some of the core outcomes through completing FYEPs which are to; demonstrate a wide range of the skills learned during their course of study; deliver a product that has passed through the design, analysis, testing, and evaluation stages; conduct multidisciplinary research through the integration of material learned in a number of courses; develop problem solving, analysis, synthesis and evaluation skills; work as a team; and to collaborate with academics and other researchers and students[1].

FYEPs require an extensive quality assurance process at every educational institution and this must be assessed by an appropriate accreditation agency. For quality assurance of the FYEP, there are two new requirements in Australia for Final Year Projects as follows:

- An Australian Qualification Framework (AQF8) requirement that it demonstrates research capability: Graduates of a Bachelor Honours Degree should have coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines and knowledge of research principles and methods[2].
- A requirement to satisfy the Threshold Learning Outcomes that is used by Tertiary Education Quality Standards Agency (TEQSA). Graduates must demonstrate an ability to: Identify needs, context and systems of problems; Apply problem solving, design and decision making methodologies; Apply abstraction and modelling skills; Communicate and coordinate proficiently; and Manage Self in the short and long term.

The literature on assessment of FYEPs has pointed to the importance of having well defined projects, good communication of expectations with students and clear guidelines for assessment by staff[3,4].Some studies report that academic staff generally adopts different approaches to assess tasks[5,6,7].Generally, a broad range of practices and a lack of consensus about what constitute a legitimate assessment task, what assessment criteria are appropriate or what level of formative assessment and support is legitimate are found in the literature[8,9,10,11,12].These variations appear to be due to insufficient preparation of and academic isolation of academic supervisors, a general lack of discussion about project expectations among faculty and lack of agreement about issues of educational task design and assessment.

The assessment process should be coherent and consistent in light of good education practices. The literature also reports that there are no definite or guaranteed assessment criteria for assessing FYEPs highlighting the need for the development of guidelines for the FYEPs and assessment criteria[1,9,10]. Practices differ greatly between universities and limited work has been initiated that seeks to identify good practice. Although some research exists on group work and peer assessment, further investigation into the methodologies behind individual project work is required[1,10,12]. This study reports practice amongst supervisors and academics involved in teaching and facilitating FYEPs in one Australian regional university. The paper outlines the typical responses received from a questionnaire conducted on learning and teaching methodology of capstone FYEPs. It also presents some of the issues and conflicts that were identified from the wider set of universities in Australia.

Methodology

A questionnaire was conducted to address the current approach to learning and teaching FYEP courses. The universities selected for the questionnaire were based on the disciplines and types of program offered (such as Bachelor of Engineering (BE), Bachelor of Engineering Technology (BET) and BE Co-op programs), mode of program (such as internal and external) and location of university (such as regional location and CBD area). An effort was made to capture the wide variety of programs offered across Australia and to include both metropolitan and regional universities. A sample of questions to students and supervisors along with on assessment and research aspects is given in Table 1.

Table 1: Sample Questions from Questionnaire

Students • What foundation are students given before commencing thesis? • Are projects conducted individually or in groups? • How do students conduct self-assessment? • How do students put forward proposals/project scopes? • What are approved methods of project management? • How are conflicts resolved between students and supervisors? • How are external students accommodated for within the course? • How are these projects managed?
Supervisors • How do supervisors typically monitor students' progress? • How are conflicts resolved between industry and academic supervisors (if industry based project)? • How academic supervisors are currently briefed in their duties? • When approving projects, what do you use to define an appropriate project scope? • How much time do supervisors spend on each student? What are workload expectations? • What are the main project factors you've identified as being related to student dependency? • What is an unacceptable level of student dependency?
Assessment • What are the key assessed components for planning and implementation stages? • How is analytical work validated within projects? • What descriptors are used for assigning grades? • How is assessment typically moderated?
Research • What categories of research sources/information are acceptable? • How are confidentiality issues acknowledged/managed?

Results and Discussion

The responses to some of the major questions from Table 1 from one of the regional universities are discussed in this paper. The university met all of the classifications mentioned in methodology, i.e. offered both internal and external modes of study for various engineering programs and disciplines of engineering, and offered both university and industry based projects under one course code. The responses have been categorized broadly into scoping of projects, students' preparation/support, supervisors' preparation/support, progress meetings and assessments. These are outlined below.

Scoping of the project

The academic supervisor serves as a valuable source of guidance for students when scoping projects, whether these are industry, university or individually sourced projects. Upon commencement of the planning phase of the final year project, students are required to outline a project proposal for their thesis undertaking. This is submitted to supervisors and the scope is negotiated at an early stage. Throughout the course of the planning and implementation phases, students must also give progress updates to supervisors, allowing them to refine the scope later if required. In the case where students undertake an industry based thesis, industry supervisors (i.e. the person responsible for supervising this project in industry) may also provide their own insights into the scoping of the selected project if appropriate.

Supervisor's training/preparation/workload

Academic supervisors are expected to have at least a Bachelor level of qualification within the engineering field, and as such are assumed to have a certain level of prior personal experience with the requirements for a Final Year Engineering Project. Although the styles of supervision tend to vary significantly depending on the student, supervisor and/or the chosen project topic, thesis efforts are somewhat unified by an interactive forum, or Learning Management System, in this case Moodle, dedicated to students and professors involved with projects. Online and/or hardcopy materials also include useful information such as course profiles, report writing guides, submission devices and key dates throughout the planning and implementation phases. These materials, whilst primarily designed for students, are also identified as important supports for supervisors.

Supervisors' workload allowances/expectations

Professors who accept supervisor responsibilities may be expected to take on anywhere from one to ten final year students per year. There is little regulation to divide the workload amongst professors, and the number of projects taken on may depend largely on the number of students with projects requiring a certain area of expertise.

Progress meetings

Students undertaking their thesis project are required to make contact with their thesis supervisor at least once every two weeks. Students are provided with a pro-forma that prompts progress to date, self-evaluation, discussion of technical issues, and development of an action plan. Students who show diligence in keeping regular and frequent contact with their supervisor can be expected to have a higher quality submission as a result. Although regular contact with supervisors is compulsory, the nature and frequency may be dependent on the discretion of each individual supervisor.

Thesis preparation and presentation

Students write a formal technical report and dissertation describing the project, the issues faced and the choices made in implementing and managing the project, the reasons for making choices, project evaluation and reflection, risk management, and what was learned from the project experience. An oral presentation of the planning stage of the thesis is held after the first term of study. This is comprised of a PowerPoint© presentation executed either in person or via prerecording or teleconference. Feedback on the project is provided from a panel of three professors, ideally with a vested interest in the subject matter. The resulting feedback sheet forms part of the compulsory assessment for the planning stage. Presentations are comprised of an A1 size poster, technical paper and ten minutes PowerPoint© presentation.

Self-assessment

Self-assessment is encouraged throughout the course of each student's thesis undertaking. When students commence project planning, a preliminary self-assessment of the student's abilities and project merits is required. A further self-assessment pro-forma is to be filled out upon completion of both planning and implementation stages. These are based upon the Engineers Australia Stage Two Competency Elements. Evaluation of project progress, strengths and weaknesses and project difficulties is prompted throughout the course of the thesis undertaking through progress updates to supervisors.

Assessment moderation

Moderation is an essential part of marking for both planning and implementation phases of the thesis undertaking. Students are provided with feedback from a panel of three professors following their project planning presentations, which informs both their planning mark and their direction during the implementation phase. Moderation is also carried out following the submission of all elements of the implementation phase.

Issues/conflicts

In the process of conducting the questionnaire with FYEP course co-ordinators and professors across the wider set of universities, a number of issues were identified. The most relevant and recurring of these issues are given in Table 2. Detailed explanation of these issues can be found in Rasul et al[1].

Table 2: Significant/Common Issues within Participating Universities

Issue	Cause/effect	Common Remedial Actions
Detrimental group dynamic	• Poor student motivation • Student personality • Conflicts • Over-dependent student • Domineering students	• Discretion in assigning grades. Head of Department assumes case to assist conflict resolution. • Select student pairs based on prior personal knowledge • Compromise/unofficial resolution where possible • Separate meetings with students • Mark contributions individually
Over-dependence of students	• Lack of ownership/initiative over project • Students looking for "soft" supervisor/topic • International students • Language issues – lack of self-expression • Project topic not aligning with students area of study/expertise	• Supervisors aim to choose students based on application to task • Supervisor assistance given carefully • Emphasis on self-guided work
Conflicting outcomes between industry and university	• Lack of understanding of academic time frame/priority among industry partners • Industry lacks prior knowledge of students' capability • Confusion between roles of consultants and students	• Enhance communication between university and industry • Industry provides thesis topic, academic supervisor tailors scope to suit capabilities of undergraduate thesis student • Ensure all industry requirements are thoroughly understood before accepting the thesis topic • Limit students' contribution to advisory/logical recommendations based firmly in research/experimentation • Establish written agreement/scope negotiation between industry and student/s

Conclusions

Identification of clear definitions of educational purposes and expectations of FYEP for both for students and supervisors is essential. Preliminary investigations into the learning and teaching methodologies exercised at Australian universities have confirmed discrepancies as indicated in the questionnaire and literature review. Further study is necessary to ensure a more transparent and repeatable process for the management and assessment of FYEPs. Common issues to be addressed, as well as development of ideas on cause and effect have been appreciated by participants during the questionnaire. In summary, this paper has laid groundwork to continue development of the FYEP learning and teaching paradigm. Further work in this area should yield tools to evaluate how well students can apply much of the knowledge gained during their University career in solving a real life problem (i.e. a best practice guideline for assessment of FYEPs). In addition, a widely acceptable approach to the outcomes based learning and teaching practices of FYEPs need to be established.

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