Guidelines for Curriculum development of Final Year Engineering Projects to support achievement of AQF8 Outcomes.

Prue Howard[a]; Colin Kestell[b], Mohammad G. Rasul[a] and Justine Lawson[a].
Central Queensland University[a], University of Adelaide[b]
Corresponding Author Email: p.howard@cqu.edu.au

Structured Abstract

BACKGROUND
A substantial project exploring the organisation, supervision and assessment of final year engineering projects in Australia has mapped practices across 16 universities. It addressed the need that although Australia has a strong history of developing FYEPs as capstone courses in engineering education, there is no national approach to curriculum development. Practices are varied and the project team has worked towards identifying good practice such that universities are better positioned to meet Australian Qualification Framework level 8 outcomes.

PURPOSE
The study set out to firstly map practices in relation to final year engineering or capstone projects and to consider the implications for compliance with AQF8 outcomes. Data from phase 1, together with the national and international literature, has been used to inform the development of good practice guidelines. These guidelines have been developed specifically to assist universities in ensuring their undergraduate engineering embedded honours degrees meet and reflect AQF level 8 outcomes in the key areas of curriculum, supervision and assessment.

DESIGN/METHOD
The project methodology was largely qualitative, adopting a case study approach. Data was gathered from 16 universities across Australia (from all states and territories) and included university documentation such as subject outlines, rubrics and student guidelines. Additionally, interviews were conducted with coordinators of final year project courses. Data was also gathered from participants during a conference workshop designed to explore understanding of AQF8. All data was coded and analysed inductively and deductively for themes. These themes were compared to the AQF8 outcomes, and the outcomes relevant to FYEP were identified. This data was then used to develop curriculum guidelines to support development of AQF8 outcomes. The guidelines have been workshopped at a range of sites throughout the second half of 2014.

RESULTS
AQF 8 identifies a range of outcomes that can be demonstrated through the outcomes of FYEP. However the curriculum needs to be consciously developed to ensure that the outcomes are developed by the students. The study has revealed great variation in curriculum development practices in FYEPs across Australian universities. The study has been able to identify guidelines for curriculum development that will support the development of AQF8 outcomes, and identify good practice as seen by FYEP coordinators to achieve the curriculum development.

CONCLUSIONS

This paper presents a summary of the guidelines and examples for curriculum development of FYEP to support AQF8 outcomes, which were developed from a large study. While there is variation in the curriculum of FYEPs across Australia, this paper gives examples of good practice that supports the development of AQF8 outcomes

KEYWORDS
Final Year Engineering Projects, curriculum, AQF

Introduction

Within the Australian context of engineering education, Engineering Schools in Australia are facing several urgent challenges in relation to their Final Year Engineering projects (FYEP), making sure that:

1. the requirements of the FYEPs meet the Australian Qualifications Framework AQF8 definition of research outcomes for Honours Bachelor Degrees and accreditation requirements for professional project research in AQF7 Bachelor Degrees
2. the FYEPs provides students with opportunities to provide evidence of Threshold Learning Outcomes for Engineering
3. assessment practices are reliable and valid and suitable for the accreditation of engineering programs from Engineers Australia and to meet Washington Accord requirements.
4. industry perceptions are adequately addressed, because these capstone experiences often open employment doors for graduates.

The FYEP is generally recognised as a capstone learning experience for any engineering program. It is the one common experience or course that all engineering students complete, no matter in which institution they study. The project gives students the opportunity to demonstrate that they can perform as a graduate engineer on an engineering project. It requires all the aspects of a professional project experience, in that they must solve an open ended, ill defined problem, integrate content knowledge, communicate with a range of people in both oral and written form, and behave as a professional. These outcomes are also the capabilities required by international engineering accreditation agreements such as the Washington Accord, International Engineering Alliance 2009. Consequently any research related to FYEPs will have relevance to engineering programs accredited under the Washington Accord.

In 2012, there were two new requirements for engineering programs, which had the potential to impact Final Year Projects:

1. An AQF8 requirement that it demonstrates research capability: *Graduates of a Bachelor Honours Degree will have coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines and knowledge of research principles and methods* (AQF, 2013) and skills to design and use research in projects.
2. A requirement to satisfy the draft Threshold Learning Outcomes that will be 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*.

Well designed and implemented, FYEPs can provide a robust vehicle for assessing attainment of threshold learning outcomes by students who are about to graduate, as well as provide evidence of the effectiveness and standards of a program of study for accreditation. Accreditation requirements (Engineers Australia, G02Rev2. 2008) “expect that programs will employ at least one major engineering project experience, which draws on technical knowledge and skills, problem solving capabilities and design skills from several parts of the program and incorporate broad contextual considerations as part of the full lifecycle.”, but a study suggests that there is no measure or guarantee of consistency (Jawitz et al., 2002).

FYEPs provide a vehicle for benchmarking program outputs nationally and internationally,however actual practices vary greatly between institutions and little work to date has been found that seeks to identify good practice (Howard et al 2013). Discussions between higher education institutions and Engineers Australia, have identified several concerns and issues. The problem to be addressed is how to develop consistency in the standard and outcomes of FYEP in Australia while maintaining the independence required within an individual program of study.

Method

This current Australian Office for Learning and Teaching (OLT) funded project 'Assessing Final Year Engineering Projects (FYEPs): Ensuring Learning and Teaching Standards and AQF8 Outcomes' has to date explored the curriculumn, supervision and assessment of FYEPs in Australia and mapped practices across 16 universities. The initial research outcomes, concentrating mainly on the educational aspects of FYEPs have been reported by Nouwens et al (2013) and Hassan et al (2013). Since then the project team has worked towards identifying good practice such that universities are better positioned to meet Australian Qualification Framework level 8 outcomes.

The project methodology was largely qualitative, adopting a case study approach. Data was gathered from 16 universities across Australia (from all states and territories) and included university documentation such as subject outlines, rubrics and student guidelines. Additionally, interviews were conducted with coordinators of FYEP courses. Data was also gathered from participants during a conference workshop designed to explore an understanding of AQF8.

All data was coded and analysed inductively and deductively for themes. These themes were compared to the AQF8 outcomes, and the outcomes relevant to FYEPs were identified. This data was then used to develop curriculum, assessment and supervision guidelines to support development of AQF8 outcomes. The draft guidelines were then workshopped at a range of sites in Australia throughout the second half of 2014.

In order for a FYEP to provide the opportunity for students to demonstrate AQF level 8 outcomes, there must be some attention to *research* activity. Given that research is a significant, though not the only point of difference between AQF levels 7 and 8, the project team sought to unpack the AQF definition of research and began to contemplate what it might mean for engineering education. The AQF (2013, p. 100) defines research as "(comprising) systematic experimental and theoretical work, application and/or development that results in an increase in the dimensions of knowledge". It was felt that this definition reflected more of a scientific paradigm and that whilst experimental work might indeed feature in engineering education, it did not fully capture the work of research in the field. The team, together with feedback from workshop participants across Australia, generated a contextualised understanding of what is involved in research in regards to FYEP work. The concept of what research means for undergraduate engineering programs is explored in Lawson, Hadgraft and Jarman (2014).

The remainder of this paper will concentrate on the guidelines that were developed for curriculum. The project as a whole is reported in Lawson, Hadgraft and Rasul (2014). The guidelines relating to assessment and supervision are discussed in Lawson, J. Hadgraft, R. & Rasul, M.G. (2014), and Martin et al. (2014). The full guidelines are available in Rasul et al (2014).

Development of the Guidelines

Initial Data

From the initial national data on curriculum, a thematic analysis was conducted on the coded data. The following themes were noted.

1. There is an overwhelming emphasis on self-directed learning in all project subjects.
2. There is some offering of workshop support (one-offs). Some sites offer regular (weekly or fortnightly) seminars and workshops.
3. In at least one instance there is provision of a parallel project management subject to assist students with all aspects of project work.
4. A number of institutions have students (graduates, post-graduates and doctoral) assist final year students through attendance at seminars etc.
5. There is some talk of the need for greater emphasis in programs on research methodologies and principles.

The one national commonality with regard to curriculum appeared to be the self directed approach to learning.

Relationship to AQF8

The draft curriculum guidelines apply to four year undergraduate engineering degrees with embedded Honours and support achievement of the level 8 learning outcomes of the Australian Qualification Framework (AQF, 2013)

As the level of research present in the program of study is one of the defining factors that differentiate an AQF 8 level program from an AQF 7 level program, it is worthwhile noting the major defining features of research within FYEPs that the project team identified. It should be noted that the following features apply regardless of the engineering discipline and/or the project type.

- Understanding the local context
- Defining the open ended problem relevant to the practice of engineering
- Mapping the state of the art globally or broadly: reviewing literature and current practices using quantitative and qualitative sources
- Identifying and articulating gaps
- Conducting systematic investigation, distillation and application to the engineering problem
- Undertaking experimentation, design, modelling, problem solving, data collection
- Analysing and synthesising with critical judgement offering unique interpretation
- Creating, innovating, publishing – making a contribution of knowledge or good practice or delivering novel outcomes in the local context
- Autonomous learning and reflecting

The draft curriculum guidelines have been structured around principles of constructive alignment in curriculum design (Biggs, 1996), and address how this practice can meet AQF8 learning outcomes. The draft guidelines were distilled from the thematic analysis of the data.

These draft guidelines are intended to help staff identify the curriculum needed to use FYEP as evidence of meeting AQF8 outcomes as part of an engineering program.

The term curriculum is used in a more enveloping sense than the term syllabus (which refers to the list of subjects or units or topics that make up the program as a whole). In this sense curriculum is taken to include whole of program design together with pedagogy and resources.

For these guidelines, curriculum will focus specifically on the development of learning outcomes and resources provided, and are complemented by the accompanying guidelines on assessment and supervision.

The Details of the Draft Guidelines

*C*1. FYEPs are not content free. The FYEP must have its own learning outcomes.

The skills and knowledge that are used in the projects may or may not be not be new to each individual student. Therefore, learning outcomes should concentrate on the development and demonstration of skills. The relationship to new knowledge may be in the processes of identifying, acquiring and using knowledge that is new to the individual student.

a. To ensure that these process based learning outcomes are developed, the FYEP should have a specific pedagogical approach (maybe PBL or other alternative). The adopted pedagogical approach should have been modelled throughout the program as a whole. It should not be new to the students at the FYEP.
b. FYEP learning outcomes should be specifically supported. There are many ways of supporting the learning outcomes, including:
    i. workshops within the project subject
    ii. parallel subjects
    iii. preparatory subjects
    iv. program curriculum prior to the project subject

C2. The project learning outcomes must be demonstrable and not assumed.

The learning outcomes must be demonstrable – in that it must be possible for the student to be able to demonstrate each and every outcome, no matter what project is chosen. Additionally, based on the concept of constructive alignment, the learning outcomes must be assessed, explicitly. It is not acceptable for staff to assume that just because the student completes a project, that the learning outcome was met.

C3. FYEPs produce common professional learning outcomes for all students. These outcomes are common for all students.

a. Research skills
b. Cognitive skills

These common professional learning outcomes will be visible through individual students' abilities to demonstrate:

a. responsibility and accountability for own learning and practice and in collaboration with others within broad parameters
b. to plan and execute project work and/or a piece of research and scholarship with some independence

C4. FYEPs will produce different technical knowledge outcomes for individual students

The technical knowledge developed by individual students may be different to each other. However, the skills demonstrated will be common:

a. responsibility and accountability for own learning and practice and in collaboration with others within broad parameters
b. to plan and execute project work and/or a piece of research and scholarship with some independence

C5. FYEPs should be supported by strong skill development prior to the project.

The project should be an opportunity to further hone skills developed throughout the program, and to demonstrate them at a higher standard than was required in the subjects or units where they were introduced. Students should not be surprised by the need to use knowledge and skills that have already been developed, such as:

a. exercise critical thinking and judgement
b. design and use research in a project
c. present a clear and coherent exposition of knowledge and ideas
d. application of knowledge and skills

To this end, program curriculum should ensure that students complete FYEPs as true capstone courses and have completed and passed the bulk of preceding courses.

C6. Projects may be offered in a variety of formats.

If being used to demonstrate AQF8 outcomes, then each format must consider how that format will impact on the manner in which the learning outcomes will be demonstrated.

a. Individual projects: i. with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

b. Team based projects:
    i. responsibility and accountability for own learning and practice and in collaboration with others within broad parameters
    ii. to plan and execute project work and/or a piece of research and scholarship with some independence

c. Cross-disciplinary projects:
    i. responsibility and accountability for own learning and practice and in collaboration with others within broad parameters
    ii. to plan and execute project work and/or a piece of research and scholarship with some independence

These guidelines are now being trialled in all states in Australia at workshops with academics from a number of institutions. The feedback relating to useability and value is being used to develop a final set of guidelines and exemplars.

Conclusions

AQF8 applies to professional engineering degrees, as they require a four year period of study with a final project. A requirement of AQF8 is a "*knowledge of research principles and methods"* (AQF, 2013) and skills to design and use research in projects. This OLT funded project has investigated the current approach to FYEPs in Australia, and identified three areas of interest. They are curriculum, assessment and supervision. Based on data gathered from universities in all states in Australia, a set of draft guidelines has been developed to help coordinators and supervisors of FYEPs use the FYEP to demonstrate achievement of AQF 8 requirements.

This paper presents a summary of the draft guidelines for curriculum development of FYEPs to support AQF8 outcomes. While there is variation in the curriculum of FYEPs across Australia, these guidelines aim to help support curriculum review of final year projects in the context of AQF8.

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