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Assessing final year engineering projects

Prue Howard [a] *, Mohammad G Rasul [b], Fons Nouwens [c]

[a]*Central Queensland University, Bruce Highway, Rockhampton 4702,Australia*
[b]*Central Queensland University, Bruce Highway, Rockhampton 4702,Australia*
[c]*Central Queensland University, Bruce Highway, Rockhampton 4702,Australia*

Abstract

The final year engineering project (FYEP) is the culminating learning experience for students within professional engineering programs. The project requires students to demonstrate that they can integrate knowledge, skills and professional graduate attributes developed during the program, and perform at a standard expected of graduates. Australian national accreditation guidelines require engineering programs to show that students are capable of personally conducting and managing an engineering project to achieve a substantial outcome to professional standards. However, in Australia, there is no clear definition of the educational purposes and expectations of FYEPs, including the assessment requirements, particularly in the key area of research skills. This paper will outline the issues and concerns currently voiced within the educational community, and outline a current project that is aiming to address these issues.

Keywords: assessment, engineering, accreditation,AQF, threshold learning outcomes

1. Introduction

Within the Australian context of engineering education, Engineering Schools in Australia are facing several urgent challenges, 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 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 project based 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. While these outcomes are what are desired from a PBL experience, they are also the capabilities required by international engineering accreditation agreements such as the Washington Accord, International Engineering Alliance 2009, to which Engineers Australia are a founding signatory.

In 2012, there are two new requirements for 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*.

In 2010, the Australian Learning and Teaching Council (ALTC) supported a project to develop Learning and Teaching Standards for engineering (Wright *et al*., 2010). This project consulted with academics, industry, graduates and students and Engineers Australia to identify Threshold Learning Outcomes (TLOs) for Engineering that defined minimum program top-level

* Dr Prue Howard. Tel.: +6-17-4930-9730
E-mail address: p.howard@cqu.edu.au

discipline skills, knowledge and professional capabilities expected of a graduate. The project clustered many indicators of competency into five major domains of competency that provide a framework for holistic curriculum development and assessment. These five TLOs provide an integrating framework that defines what graduates are expected to know, understand and be able to do as a result of their learning. The report suggests that *as part of a final year project, a student approaching a complex problem … will use the full range of outcomes (page 7).* The report also suggested that *there is little common dialogue across institutions and industry regarding standards*. What was very evident, however, was the importance of establishing clear standards (page 9). The report also rose as an issue for standards and assessment the need to find ways of providing evidence of achievement of TLOs in ways that all stakeholders could accept with confidence.

To provide a reliable indicator of student capability and program quality and standards, FYEPs must be coherent, valid and reliable instruments for student assessment and program evaluation. An investigation of assessment practices in FYEPs at Australian and New Zealand universities (Rasul *at el*. 2010) was conducted by some of the authors of this paper. It identified concerns with assessment of complex projects and difficulties in developing assessment criteria, assessment of individuals in team's projects, alignment of industry and academic interests in projects, difficulty in scoping projects and assigning appropriate projects to students and workload and availability of staff for project supervision. There is very little dialogue or collaboration between institutions, each dealt with problems in different ways. The lack of standard assessment invites benchmarking to identify good practice.

2. What is known

A recent ALTC funded project considered development of assessment practices for project based subjects that were team based (Howard & Eliot 2012). While this project dealt mainly with the issues of assessing individuals within teams, it also uncovered the underlying issues of staff attempting to assess students against learning outcomes, when the project is the context for learning. In this study one of the problems identified was whether the academic was attempting to assess the product or the learning itself.

Other studies reveal large variations in the way FYEPs are managed and assessed (Jawitz *et al*., 2002). Oehlers (2006) identifies some of the challenges in assessing engineering project work. The issues he identifies are consistent with those found elsewhere for final year projects in disciplines other than engineering (Tribe and Tribe, 1988; Webster *et al*., 2000).

The literature shows a broad range of practices and a lack of consensus about what constitutes a legitimate assessment task, what assessment criteria are appropriate or what level of formative assessment and support is legitimate (Armstrong *et al*., 2005; Oehlers, 2006; Blicblau, 2006; Seidel *et al*., 2006; Kuisma, 2007; Mills, 2007; Beckerleg and Collins, 2007; Rasul *et al*., 2009; Cochrane *et al*., 2009; Valderrama *et al*., 2009; Rasul *et al*., 2010; Rasul *et al*., 2012). Much of the variation appears to result from insufficient preparation of and academic isolation of academic supervisors, a lack of general discussion about project expectations among faculty and lack of agreement about issues of both educational task and whole of program design and assessment. Eliot et al 2012 and Howard & Eliot 2012 also identified a lack of understanding by academic staff about alignment of learning outcomes and assessment as an issue in project based subjects.

A review of ALTC projects identified development work in areas related to assessment and group work, but not to final year or capstone courses. ALTC projects included work on assessing individual work in teams (ALTC 2009, priority project: Assessing individual learning in teams: developing an assessment model for practice based curricula in engineering), assessing group work (ALTC 2005, priority project: Assessing group work in media and communications) and on supporting peer assessment and review in large group work projects (ALTC 2006, priority project: Supporting student peer assessment and review in large group work projects). Such work will be useful where programs require that capstone FYEPs involve student collaboration, but many engineering programs in various universities require individual project work. Other ALTC projects supported development of tools for competency and skills assessment (ALTC 2007, competitive grants project: The development of an undergraduate nursing competencies assessment tool for use across Australian Universities; ALTC 2006, priority project: LinuxGym—A sustainable and easy-to-use automated developmental assessment tool for computer scripting skills). Again, this work may be drawn on in developing criteria frameworks for capstone assessment of competencies and skills, but the work does not address specific requirements of project assessment. Further study is essential to address the problems identified above.

3. Identifying the problem

Reliable and valid assessment practices are central to the integrity of the qualifications offered at universities and are thus a legitimate focus for quality assurance. 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 currently there is no measure or guarantee of consistency as mentioned earlier. Such projects provide a vehicle for benchmarking program

outputs nationally and internationally. However actual practices vary greatly between institutions and little work has been found that seeks to identify good practice. 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.

4. What is proposed

This project can effect positive change in learning and teaching in the discipline, profession, sector, nationally and internationally. The project team intend to address these concerns and issues by surveying current practice in FYEP and developing a community of FYEP practice to identify good practice guidelines and test resources for students, supervisors and coordinators. Surveys and development of guidelines and resources will be focused on the following areas:

- Support for Students: While the curriculum may scaffold development of students' capacity to undertake projects through project-based learning (PBL) and work-integrated learning (WIL), the FYEP represents a major extension of expectations regarding a student's capacity to conduct a project. In identifying resources that can be made available to help students manage their projects, questions about the appropriate balance between support and exposure to real-life complexity need to be addressed. Student guidelines and resources will be produced and tested.
- Preparation for Academic Staff: Final year project assessment is vulnerable to variation in the quality of supervision because a large number of projects need supervision each year requiring many academics, each of whom may advise students differently about project expectations. Identification and description of good practice would provide academic supervisors with resources for induction and staff development and clear expectations about the supervisor's role.
- Preparation of Industry Clients and Supervisors: Many universities promote industry involvement in FYEPs. Industry partners provide valuable exposure to professional practice and gain access to prospective graduates. However industry client's expectations about project outcomes may not align well with academic requirements. Industry projects may also involve intellectual property and confidentiality issues that require sound guidelines. Authoritative explanatory guidelines would assist industry partners to understand the educational context and expectations of FYEPs.
- Selection of Projects: The kind of project a student selects can influence a student's learning. Routine projects may not provide scope for students to demonstrate high levels of professional capability and obtain a high grade. There is debate about what kinds of FYEPs are acceptable and the kinds of professional competence that projects should allow students to demonstrate. A survey to identify good practice and develop guidelines about project selection would assist students and supervisors identify appropriate projects. Such questions affect evaluation of program standards so they would involve some elaboration of accreditation requirements and consultation with Engineers Australia.
- Project Assessment: Assessment can take into account different elements (e.g. supervisor's report, technical report, design portfolio, journal, poster, oral presentations, weightings for technical quality, etc). The criteria for grading projects use various rubrics that influence assessment and benchmarking processes. In relation to holistic assessment of Threshold Learning Outcomes, the particular issue in assessment is the balance between the product or outcome of the project on the one hand, and on each student's professional development as an engineer on the other. Best practice guidelines for assessment would provide a basis for more consistent application of standards.
- Standards for Research: Accreditation guidelines require students to demonstrate information literacy and basic research skills, however the AQF framework distinguishes between an AQF7 Bachelor Degree and an AQF8 Bachelor Honours Degree while allowing the Honours program to be embedded in a four year Bachelor Degree. The AQF distinguishes between AQF7 and AQF8 in terms of project work, research skills but accreditation would require completion of projects in the AQF7 Bachelor Degree. There is also a need to define the both the purpose and standard of project research required by accreditation for both AQF7 and AQF8. Is the aim of research to provide a vehicle for developing professional skills, or is the research intended to produce significant new knowledge? Broad academic consensus is required to ensure that students are treated equitably fairly.
- Standards for Project Reports: A standard outcome of an FYEP is an extended report or portfolio. It is important that students receive clear advice about requirements and an appropriate level of support in preparing their reports because the FYEP report will often be the first extended report students have prepared. If project assessment is based on report moderation (i.e. only on the evidence presented by students in the report), supervisors and moderators also need shared expectations for assessment, and supervisors must advise students of these expectations. A survey of current good practice and articulation of discipline guidelines would assist both students and supervisors.
- Curriculum Integration: Recent consultations to develop the set of Threshold Learning Outcomes for engineering provides a more holistic framework that can be used to interrogate learning outcomes specified for project courses, and for how a program of study is designed to lead students to successful completion of projects and to become capable and confident professionals. This project would provide a vehicle institutions could use to review curriculum in terms of the TLOs.
- Coordination and Supervision of Projects: A FYEP coordinator is usually appointed to coordinate academic administration of all project courses within a program or discipline area. Then for each project, an academic project

supervisor provides learning support and contributes to assessment. Projects are individualised, time intensive and involve workload formulas different from those used in other courses. Some students and projects require more time than others. Students need access to staff who are prepared to and capable of providing the required project support. An understanding of current staff development practices for undergraduate project supervision skills is required to inform the development of best practice guidelines for staff development to promote quality assessment.

These issues and concerns must be addressed to achieve consistency and fairness in formative assessment and support for students, valid and reliable summative assessment of prospective graduates, and program standards within and across engineering programs in any faculty of any university. The resulting guidelines and processes from this project could serve as a benchmarking tool for all engineering schools.

5. What has been done

A pilot project was conducted in Australia to investigate how final year projects are assessed currently. A small number of institutions took part in the study. The literature indicated that a broad range of universities offering FYEP courses identified a number of key issues of concern relating to teaching and learning practices. In particular, a general lack of consensus on teaching and learning methodologies and project scoping came to the forefront. "Discussions among practitioners involved in scholarship in engineering education indicate that universities are failing to use FYEPs effectively, partly because FYEPs are different from most other undergraduate courses, and FYEP coordinators are professionally isolated". Such issues may "result from insufficient preparation of and academic isolation of academic supervisors, a lack of general discussion about project expectations among faculty and lack of agreement about issues of educational task design and assessment". (Rasul, et al (2009).

The pilot report concluded that there are major discrepancies between the institutions in the way that they assess FYEP.

6. Conclusions

The FYEP is the student work that can be used to demonstrate that the AQF8 requirements and Threshold Learning Outcomes have been met by a professional engineering degree program. Currently there are no national guidelines or specified requirements for institutions to use in ensuring that their FYEP meet these requirements to ensure consistency throughout the nation.

Previous studies have identified issues with the knowledge and understanding of some academic staff to allow them to separate the product of the project from the learning within the project. Other studies have identified the issues relating to inconsistency both within and across institutions.

A project has been approved and funded to investigate the current assessment practices within FYEP across Australia and to develop guidelines for staff and students. This project is being funded by the Office of Learning and Teaching (OLT) and is supported through the reference group by Engineers Australia. The project will survey and critically review coordination, supervision and assessment practices of FYEPs in universities and disciplines of engineering, and then develop and promote an FYEP assessment model and benchmarking guidelines to assist engineering disciplines to improve FYEP assessment. This project is running over two years and started in January 2013.

At this stage, the project is collecting data from across the country on how the projects are set up, where they come from (industry or acadaemia), how they are supervised, what percentage of study load is attributed, how they are assessed, how they are moderated and what level of research is included. The major point of interest will be to compare how individual institutions use the project to demonstrate how individual students can apply the knowledge and skills developed over the course of their study.

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7. References

AQF2013, Australian Qualifications Framework, Published by Australian Qualifications Framework Council, Second edition January 2013, http://www.aqf.edu.au

Armstrong, P. J., Kee, R. J., Kenny, R. G., and Cunningham, G. (2005), A CDIO approach to the final year capstone, *Paper presented at the 1st Annual CDIO Conference*, 7-8 June 2005, Queen's University, Kingston, Ontario, Canada.

Beckerleg, M., and Collins, J. (2007), Producing research from undergraduate projects. In H. Sondergaard & R. Hadgraft (Eds.), *Proceedings of the 18th Conference of the Australian Association for Engineering Education, 9–13 December 2007*, Melbourne, Australia.

Blicblau, A. S. (2006), Capstone Portfolios for Learning and Evaluation, in G. Rowe & G. Reid (Eds.), *Proceedings of the 17th Annual Conference of the Australasian Association for Engineering Education, 10–13 December 2006*, Auckland, New Zealand.

Cochrane, S., Goh, S. and Ku, H. (2009), An investigation into the application of research strategies in the final year engineering and surveying projects, in C. Kestell, S. Grainger and J. Cheung (Eds.), *Proceedings of the 20th Annual Conference of the Australasian Association for Engineering Education, 6-9 December 2009*, Adelaide, Australia.

Dong, C. (2012), Assessment mechanical engineering final year projects using Fuzzy multi-attribute utility theory, *Research and Development in Higher Education, Vol 43, 23-30*.

Eliot, M., Howard, P., Nouwens, F.,et al. 2012 *Developing a Conceptual Model for the Effective Assessment of Individual Student Learning in Team-Based Subjects*, Australasian Journal of Engineering Education Vol 18, Number 1, pp105 – 112, 2012

Engineers Australia (2006), *PO5 rev1: Engineers Australia National Generic Competency Standards—Stage 1 Competency Standards for Professional Engineers*.

Engineers Australia (2011), *Stage 1 Competency Standard for Professional Engineer*. Canberra Australia.

Howard, P & Eliot, M. (2012) *A Framework for Assessing Individuals who Learn in a Team Environment* Proceedings of the 23nd Annual Conference for the Australasian Association for Engineering Education. Melbourne, Australia, 5-8 Dec 2012

International Engineering Alliance (2009), *Washington Accord,* International Engineering Alliance, http://www.ieagreements.org/Washington-Accord/, Accessed 23June 2009.

Jawitz, J., Shay, S., and Moore, R. (2002), Management and assessment of final year projects in engineering, *International Journal of Engineering Education, 18*(4), 472–478.

Kuisma, R. (2007), Portfolio assessment of an undergraduate group project, *Assessment & Evaluation in Higher Education, 32*(5), 557–569.

Mills, J. E. (2007), Multiple assessment strategies for capstone civil engineering class design project, in H. Sondergaard & R. Hadgraft (Eds.), *Proceedings of the 18th Conference of the Australian Association for Engineering Education, 9–13 December 2007,* Melbourne, Australia.

Oehlers, D. J. (2006), Sequential assessment of engineering design projects at university level. *European Journal of Engineering Education, 31*(4), 487–495.

Rasul, M.G., Nouwens, F., Martin, F., Greensill, C., Singh, D., Kestell, C. and Hadgraft, R. (2009), Good practice guidelines for managing, supervising and assessing final year engineering projects, in C. Kestell, S. Grainger and J. Cheung (Eds.), *Proceedings of the 20th Annual Conference of the Australasian Association for Engineering Education, 6-9 December 2009,* Adelaide, Australia.

Rasul, M.G., Nouwens, F., Martin, F. and Greensill, C. (2010), Benchmarking in assessment of final year engineering projects, *CQUniversity Internal learning and Teaching Report*, Australia.

Rasul, M.G, Nouwens, F., Swift, R., Martin, F. and Greensill, C. (2012), Assessment of Final Year Engineering Projects: A Pilot Investigation on Issues and Best Practice, In M.G. Rasul (edit), *Developments in Engineering Education Standards: Advanced Curriculum Innovations, Chapter 5, 80-104*, IGI Global Publisher, USA. ISBN 13: 978-1-46660-951-8.

Seidel, R. H. A., Tedford, J. D., and Islam, M. A. (2006), Assessment of the effectiveness of team and project based learning in engineering education. In G. Rowe & G. Reid (Eds.), *Proceedings of the 17th Annual Conference of the Australasian Association for Engineering Education, 10–13 December 2006*, Auckland, New Zealand.

Tribe, D., and Tribe, A. (1988), Assessing law students: lectures attitude and practices, *Assessment and Evaluation in Higher Education, 13*(3), 83–93.

Valderrama, E., Rullan, M., Sanchez, F., Pons, J., Mans, C., Gine, F., Jimenez, L. and Peig, E. (2009), Guidelines for the final year project assessment in engineering, *The 39th ASEE/IEEE Frontiers in Education Conference, Session M2J*.

Webster, F., Pepper, D., and Jenkins, A. (2000), Assessing the undergraduate dissertation, *Assessment and Evaluation in Higher Education, 25*(1), 71–80.

Wright, S., Hadgraft, R., and Cameron, I. (2010), *Engineering and ICT Academic Standards Statement*, Learning and Teaching Academic Standards Project, Australian Learning & Teaching Council, Department of Education, Employment and Workplace Relations, SydneyStrunk, W., Jr., & White, E. B. (1979). *The elements of style*. (3rd ed.). New York: Macmillan, (Chapter 4).