International Journal of Engineering Education Vol. 32, No. 1(B), pp. 348–363, 2016
Printed in Great Britain

0949-149X/91 $3.00+0.00

Assessment in PBL—Do We Assess the Learner or the Product?*

PRUE HOWARD, MATT ELIOT, MOHAMMAD G. RASUL, FONS NOUWENS and JUSTINE LAWSON
Central Queensland University, Bruce Highway, Rockhampton, Queensland, 4702, Australia. E-mail: p.howard@cqu.edu.au, m.eliot@cqu.edu.au, m.rasul@cqu.edu.au

Grading individual students in teams or projects has always been problematic. To accurately gauge individual learning outcomes, students' grades need to be based on what they have learned as an individual within the team or project context. However, within engineering team-based projects, individuals have traditionally been assigned a grade heavily influenced by the team's project outcomes. Final year engineering projects (FYEP) suffer from similar problems. While typically in the Australian context, the projects are conducted by individuals, they are still conducted using the philosophy of PBL. 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. This paper considers two Australian engineering education projects, one recently completed and one current, that investigate the issues of; how can individuals who learn in a team environment be assessed as individuals?, how can the outcomes from final year engineering projects be used to demonstrate the standards required by various state and professional accrediting agencies? And what are the issues that prevent staff effectively assessing the learning outcomes of individual students who learn in the project environment? The paper outlines an assessment model that was trialled and discusses the issues arising. The difference between this form of assessment and others in engineering education is that it assesses the learning outcomes of the individuals as opposed to assessing the product of the team. The paper also discusses the results from the first stage of data gathering on final year projects in Australia. The conclusion is that assessing the product rather than the learner degrades the opportunity to use projects as evidence of learning, but continues because it is easier for academic staff.

Keywords: assessment; teams; PBL; engineering

1. Introduction

Grading individual students in teams or projects has always been problematic. To accurately gauge individual learning outcomes, students' grades need to be based on what they have learned as an individual within the team or project context. However, within engineering team-based projects, individuals have traditionally been assigned a grade heavily influenced by the team's project outcomes. Consequently, a poor project outcome for a team results in poor grades for its individual members, even if significant individual learning occurs. As assessment drives behaviour, the desire for higher grades influences the team dynamics. This results in an emphasis on project outcomes rather than individual learning, potentially degrading collaborative learning [1, 2]. While some research has been conducted on team formation and monitoring to help reduce these effects, [3], it does not assess individual learning in teams.

The recent Australian Learning and Teaching Council (ALTC)-supported project "Engineers for the Future" [4] recommends the development of best-practice engineering education to promote student learning and deliver intended graduate outcomes. This project follows the 1996 Australian report "Changing the Culture [5], which first highlighted the need for change to an outcomes-based engineering education system in Australia. Implemented changes to student learning and graduate outcomes have since resulted in a greater emphasis on team-based projects within the Australian context. This requires a dramatic change to the traditional methods of assessing individuals within teams in engineering as they do not currently meet the assessment needs of practice-based education, such as project-based learning (PBL). PBL-based courses should differ significantly from traditional engineering courses in that the project forms the context for student learning, instead of being the assessable deliverable for the course. The project provides an ill-defined engineering problem in which students learn in a team environment. Students must, with the help of facilitated learning sessions and self-directed learning, identify what knowledge and skills are required to complete the project, which of those exists within the team, and which must be gained and applied to the project.

Qualitative assessment methods are more suited than quantitative methods in assessing graduate attributes in PBL in terms of the broader, professional, context-dependent skills required of an engineering student. Qualitative methods allow students

* Accepted 11 August 2015.

to discuss and justify their understandings. These contrast with the quantitative assessment methods generally used in engineering courses. They are typically used to assess specific, technical content knowledge, which tends to require right or wrong processes and answers. This aligns with the scientific and judgemental models suggested by Hager and Butler [6]. The majority of engineering academics and industry professionals understand and are more comfortable with quantitative assessment methods. Experience with accreditation teams in Australia has shown their mistrust of qualitative assessment, with accreditation teams often commenting that qualitative assessment is subjective and is therefore not a valid or reliable method of assessment in engineering. While this is anecdotal evidence, the situation has happened in Australia enough times for the problem to be recognised. Yet it is these qualitative methods that assess critical engineering skills, such as design thinking.

This research team argues that the basis of grading decisions in practice-based education such as PBL needs to disassociate the learning environment (the project) from the result (grade). It should instead focus on an individual student's learning. A student's grades in a particular team-based subject should reflect what she or he has learned as an individual within the team context. This learning is often framed in terms of the learning outcomes embedded in the course design. The need to assess individual student learning is often at odds, however, with the realities of the assessment process. Many instructors work within constraints such as student numbers, workload pressures, and limited expertise in assessment itself. As a result, individual students within engineering team-based project subjects are often assigned a grade heavily influenced by the team's project deliverables. This use of team-created deliverables as indicators of individual student learning has multiple potential problems. For example, a less-than-successful project often results in reduced grades for its individual members. This can be both unfair to students and professionally unethical for academics. The conditions and actions that constitute project "failure" are often the source of significant learning.

In addition to discerning individual student learning, assessment practices themselves are used inconsistently in engineering team-based subjects. The quantitative assessment methods generally used in engineering subjects assess specific, technical content knowledge, which tends to require right or wrong processes and answers. Qualitative assessment methods, however, are more suited than quantitative methods in assessing students' engagement with graduate attributes in engineering project-based learning (PBL) subjects, particularly in terms of the broader, professional, context-dependent skills developed in this pedagogical approach.

Final year engineering projects (FYEP) suffer from similar problems. While typically in the Australian context, the projects are conducted by individuals, they are still conducted using the philosophy of PBL. The team however now resembles more a professional team of engineer (student), supervisor, technical support and client. As many universities use the FYEP as demonstration of the final outcome of an entire program, the assessment is critical to demonstrating graduate outcomes and program standards. 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 [7] was conducted. It identified concerns with assessment of complex projects and difficulties in developing assessment criteria, assessment of individuals in team 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. The paper indicated that there is very little dialogue or collaboration between institutions within Australia, with each dealing with problems in different ways. The lack of similar assessment practices invites benchmarking to identify good practice.

Other studies have revealed large variations in the way FYEPs are managed and assessed [8]. Oehlers [9] 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 [10, 11]. 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 [9, 12–21]. 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. It has also previously been reported that there is an identified lack of understanding by academic staff about alignment of learning outcomes and assessment as an issue in project based subjects [22, 23].

This paper gives an overview of two projects, both funded by the Australian Office of Learning and Teaching (OLT), which have investigated the two related issues of assessing individuals who learn

within a team environment and the assessment of final year engineering projects. The first project, (Assessment In Teams—AIT), was conducted over a two year period. The early stages of the project have been reported on in previous publications [22, 24–25]. This paper concentrates on the later stages of the project, where a pilot was conducted to trial the assessment model developed by this project, and the overall findings of those pilots. The aim of this project was to develop a summative assessment model that allowed the assessment of students as individuals, when they do their learning in a team environment. The model aimed to capture both technical/scientific knowledge, as well as higher order processes. The hallmarks of team-based project-oriented subjects are higher order processes such as design thinking, communication, and teamwork. The second project (Final Year Projects—FYP) which was still running at the time of writing, has a stream which is investigating the current assessment practices of final year projects in the Australian context. This project has been informed by the first (which was based around 4 Australian institutions), and is identifying similar issues for Australian engineering academics across the higher education sector.

2. Research questions

At the start of these projects, the engineering discipline in Australia did not have a valid method for qualitatively assessing individual learning in a team environment accepted by the accreditation body for engineering programs (Engineers Australia), as well as engineering academics and industry. This was evident through the accreditation experience and Engineers Australia's response to accreditation visits. This has been a major challenge to the acceptance, accreditation and implementation of PBL. However, it is also an issue for all engineering programs, which must demonstrate graduate outcomes from complex tasks such as final-year design and research projects. 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. Accreditation teams spoke of needing such outcomes. While to many this language meant that the outcomes should be scientifically repeatable, in reality they meant that the accrediting bodies must trust and have confidence in the assessment processes. It is critical that the accreditors have confidence that the processes will be consistent. The process should be independent of the individual academic using it. The academic community needs to have faith in the outcome of the assessment tool. Well designed and implemented FYEPs can provide a robust vehicle for assessing attainment of threshold learning outcomes by students who are about to graduate. Additionally, they provide evidence of the effectiveness and standards of a program of study for accreditation.

Accreditation requirements [26] "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.

These two projects together seek to identify:

- How can individuals who learn in a team environment be assessed as individuals?
- How can the outcomes from final year engineering projects be used to demonstrate the standards required by various national and professional accrediting agencies?
- What are the issues that prevent staff effectively assessing the learning outcomes of individual students who learn in the project environment?

As these two projects have run for a number of years, the outcomes at various stages have been reported on in a number of publications. This paper will concentrate on the final outcome of the AIT project and the intermediary stages of the FYP project (informed by the AIT project).

3. Methodology

3.1 Research design

Both of these projects followed a similar methodological approach. The AIT project aimed to answer the first research question, while the FYP project aimed to answer the second question. The third question was then to be answered through the piloting of the outcomes of the two projects. A qualitative approach was taken, as the authors recognized the context dependent nature of the questions. The approach uses a social constructionism approach that is an interpretivist paradigm. This paradigm acknowledges that human beings can interpret their surroundings [27]. Interpretivist paradigms recognize that social science data is often mediated through personal "stories," and that facts and values cannot be separated.

The AIT research and development project used a synthesis of design research [28, 29] and Grounded Theory inquiry [30, 31]. Design research offers an

epistemological approach to investigating theoretical constructions of learning and teaching in the "real world" context of the working classroom. Grounded Theory, a research paradigm founded in the social science context, offers the opportunity to explore participants' lived experience for the purposes of generating theory. In this case it is a model of effective assessment of individual students' learning in team-based pedagogies such as PBL. For this project, effective assessment meant a confidence by the assessor that the learning of the individual was being assessed, not the outcome of the team. Additionally, effective meant that the desired aspect was being assessed. That is the learning of the individual not the quality or correctness of the product or artefact produced by the team. This Grounded Theory methodological approach is particularly relevant to this study as it allows the answer to come from the data, rather than starting with a hypothesis and attempting to prove it. As the research team was attempting to determine how the individual could be assessed, we were not presupposing any right or wrong answers. The design research approach then allowed us to design potential solutions based on the data that came from the Grounded Theory approach.

The FYP project used a case study methodology as the research question that it was attempting to answer was an in depth study of a particular or unique situation. As Felder and Hadgraft suggest [32], this qualitative approach is best suited to this type of exploratory study of how a project allows demonstration of the competencies. The similarity to the AIT project is in the second stage where following a research design methodology, the outcomes from the case study were then used as the data for the development of guidelines.

Boyer's model of scholarship [33] is an action-scholarship methodological approach that is based on critical reflection of the practice of teaching in such a way that new knowledge and understanding emerges. The outcomes aid the profession by integrating knowledge from across disciplines and applying this to the identified problems. This approach to teaching models the professional behavior that programs seek to develop and promote. Boyer's model aligns with a Grounded Theory approach to the enquiry, which is based on the idea of outcomes emerging from the enquiry rather than being predetermined.

3.2 Data collection and analysis

In both projects, the research teams conducted open-ended interviews with academic staff and students about their experiences. In the AIT project, the interviews focussed on experiences with assessment in the team-based setting. In the FYP project, the interviews focussed on how final year projects are actually conducted. The interview transcripts were then analysed for recurrent and outlying themes. In the AIT project, the findings from this analysis then informed the construction of a broad working model for effective assessment of individual students' learning in team-based courses. This model was then used to create assessment strategies for specific team based courses at the project member institutions. In the FYP project, the findings were used to develop guidelines for good practice in Final Year Project development. In both cases the outcomes were piloted. The evaluation of these pilot assessment strategies then in turn helped refine the broad assessment model and the guidelines. As members of the research team were involved in teaching at each institution, for each project, a single interviewer was used for every interview.

3.2.1 Assessment in teams project

Publicly available documentation regarding the assessment of team work was collected from each member institution. This documentation included unit profiles, project outlines and assessment items including marking criteria where available. This information was aimed at providing an overall understanding of the similarities and differences between the institutions and their approaches to teamwork and assessment. This understanding by the project team was used to help in the open ended interview development.

Open-ended interviews with academic staff and focus groups with students were conducted by the research officer. At each of the member institutions, staff and students were given the opportunity to talk about their experiences with assessment in the team-based setting. Interviews were conducted with academic staff in a variety of roles: Heads of program, lecturers, curriculum designers, those who teach in PBL-based programs, and those who teach stand-alone team-based subjects in more traditional engineering programs. The data collection focused on the purpose and goals of assessment, the strengths and weaknesses of current assessment methods in a team-based learning environment, and optimal assessment practices. The student focus groups gathered data on the impact of current assessment methods as well as students' ideas for more effective methods of assessing an individual student's learning in teams.

The interview and focus group transcripts were transcribed and de-identified. A thematic analysis was then conducted to identify recurrent themes and outlying data points [34]. The data analysis was conducted by the research officer initially, and then by two members of the research team to

reach a consensus regarding the themes and outliers. This data revealed a range of considerations that participants employed when designing and implementing assessment of both individuals and teams. These considerations were identified in three main categories of content, process and context. Within these three categories there were 14 themes. These will be discussed in the findings section.

Based on these considerations, the research team then constructed a conceptual model for assessing individual student learning in team-based learning environments. This model also took into account relevant literature sources and the team's own professional experience in this context. The conceptual model is presented in the findings and discussion section of this paper as Fig. 1. After workshopping this conceptual model at a number of educational conferences, the research team then developed a set of guiding principles for effective individual assessment in the team-based environment. These were then instantiated into a workable strategic assessment framework. This framework was piloted in undergraduate engineering subjects at four Australian universities in Term 2 of 2011. The purpose of these pilot projects was to test the construct validity of the conceptual framework and to explore issues around its implementation. The evaluation of these pilot assessment strategies then in turn helped refine the broad assessment model.

3.2.2 Final year projects project

This project comprised two phases. The first being the case study phase, which was a mapping and review of existing assessment and supervision practices. This was followed by the development and promotion of guidelines to assist engineering disciplines to improve FYEP assessment.

Data from phase one included collection of documentation from 16 universities from all states and territories of Australia. Documentation included course profiles, student guidelines, marking rubrics, schedules, and teaching resources and exceeded 100 documents. In addition, semi-structured interviews were conducted with 16 individual coordinators of capstone project courses across a range of ten Australian universities. The wider project team members approached coordinators from their own institutions as well as those with whom they were connected. The research officer conducted all interviews. The interviews allowed participants to explain their documentation and their practices, and in particular to articulate the strengths and challenges of assessment and supervision. Interviewees were prompted with questions such as:

- Tell me about some of the challenges you face with your final year project course.
- What do you see as some of the strengths of the way you do things?
- How are supervisors involved in the assessment and why do you do things this way?

The interview data supplemented and explicated the extensive documentary data. This data was coded thematically initially from the themes pre-set by the research proposal but then inductively for a more fine grained approach to analysis. Using the data from phase one, the team developed draft guidelines in the areas of curriculum, supervision and assessment. Accompanying exemplar practice was developed drawing on both the literature pointing to best practice and identified strengths from the coordinator interview data. These guidelines and practices were then presented at seven workshops throughout Australia and feedback sought, recorded and analysed from participants. Using this feedback a revised set of guidelines was presented and evaluated at a final workshop. The revised guidelines were also distributed for comment to all previous participants. This second phase drew on feedback from over 100 people from 26 universities. The final set of guidelines responded to the final feedback set.

4. Finding and discussion

When considering the outcomes of both projects, the common elements were the project focused nature of the teaching environment, and the element of assessment as an issue of concern. While the curriculum starts with aims and needs, the students start with assessment. Therefore the assessment needs to be carefully structured to ensure that the student learning achieves the desired outcomes [35].

4.1 Assessment in teams project

The partner institutions in this project were strategically chosen. Two of the institutions currently deliver their engineering programs using PBL as a program philosophy, and another two institutions had on staff nationally recognised experts in PBL. A fifth institution, while not a full partner in this project participated as a supporting partner. They are a recognised leader in PBL education internationally, including engineering.

In the first phase of our project, we interviewed academic staff at our 5 member institutions about their assessment practices. The following three categories and 14 themes emerged from the analysis of interviews. Together they briefly describe the considerations they reported as related to their assessment processes. Some readers might be looking for frequency (number of comments or number of participants) within these considerations as an indicator of relative importance. As a qualitative

study however, it is important to note that this data collection activity was intended instead to gather a wide range of perspectives on assessment in team-based coursework. Saturation of the data occurred when no new perspectives were identified in fresh transcripts.

4.1.1 Content considerations

4.1.1.1 Assessing technical knowledge and skills

Team-based project subjects offer an important opportunity to combine both technical knowledge and professional skills within a single integrated learning environment. In terms of assessing technical knowledge, participants reported that written examinations were often seen as the exemplar method of assessment. Although some participants also reviewed workbooks and reflective journals. Oral examinations were reported as offering a more comprehensive method for exploring the strengths and limits of a student's technical knowledge and skills.

4.1.1.2 Assessing professional knowledge and skills

In addition to technical knowledge and skills, participants reported taking professional knowledge and skills into consideration. Skills such as teamwork, working with clients, and the ability to facilitate interactive presentations. Participants sought evidence of student professionalism in their documentation and presentations, by oral examination, and by direct observation of team interactions.

4.1.1.3 Assessing broad understanding

The term "broad understanding" here refers to an individual student's learning in the areas of the project outside of the specific section they themselves have focused on. Student teams often break complex projects into subsections, with an individual student focusing on a single section. While there are many benefits to this approach, one obvious downside is that students may lack a holistic perspective. The outcome being that they do not engage substantively with other aspects of the project which are vital to their overall learning.

Participants reported that the assessment process was a primary incentive that can motivate students to build broad understanding in team-based project subjects. Participants reported instilling expectations for broad understanding from the beginning of the subject. Some then used oral exams at the end of term to explore the multiple areas of a single project. It is important to note that while broad understanding was seen as important by participants, when pressed these participants were sometimes unable to describe concrete standards by which it could or should be measured.

Participants also reported that assessing for broad understanding was an effective way to identify those "passenger" students who have minimal input or engagement with the team project and rely on the other team members to complete it.

4.1.1.4 Assessing design thinking

For the purposes of this project, design thinking is being defined as the chain of reasoning within individuals and teams which leads from problem identification to solution development and evaluation. Participants in this research project sought to assess students' design thinking:

1. as a key engineering skill,
2. as a method for assessing multiple competencies including technical knowledge and skills, teamwork, and broad understanding, and
3. as a method for identifying passenger students.

Participants reported that written evidence (such as a report or a written exam) was limited in its ability to reveal design thinking, with reflective journals offering at best a limited perspective. Several participants used oral examinations to explore and assess design thinking. Often this was with an emphasis on exploring an individual student's understanding of key decision points in the design process.

4.1.2 Process considerations

4.1.2.1 Determining individual contributions to team deliverables

Participants in this study frequently described a need to determine which students worked on particular aspects of a team deliverable such as a report or a presentation. This was seen as an important aspect of assessing an individual student's learning. In addition, participants framed this need in terms of fairness for students, referring to it as a method for identifying passenger students.

To better determine an individual student's contributions to their team's deliverables, participants variously reported doing the following:

- direct observation of teams;
- supervisory meetings with teams;
- requiring explicit attribution in presentations and documents;
- requiring the submission of team meeting minutes; and
- creating "milestone" assignments throughout the term that could involve contributions from both individual students and their teams.

4.1.2.2 Assessing a team's dynamics and the impact on an individual student's learning

Participants in this study recognised that the quality of team interaction could have a significant impact on an individual student's learning. To better under-

stand team "health", participants used direct observation. This occurred in supervisory meetings, and peer assessment to look for positive team interaction as well as power imbalances and significant differences in contribution.

4.1.2.3 Assessing international students
Participants expressed concerns about assessing international students within their subjects. The issues related to varying levels of English language skill, possibly mismatched expectations about classroom behaviour, the need for local knowledge (i.e., Australian standards), and prior experience with hands-on laboratory sessions. Participants varied in their response to these concerns, ranging from holding international students to less rigorous standards, to expecting international students to demonstrate knowledge and skills at levels equal with domestic students. Many participants talking about this consideration, however, simply described the situation as "difficult" without articulating how they personally responded to it.

4.1.2.4 Use of formative assessment opportunities
Many participants in this project recognised that formative assessment opportunities could be offered at strategic points across the term. They identified these were necessary to keep teams "on track" toward the completion of the team project with its embedded learning goals. Formative assessment opportunities included reports (such as design briefs or requirements reports), shorter written assignments (such as status reports) and presentations. A few participants used only summative assessment measures implemented at the end of term, suggesting they also offered students and teams verbal formative guidance throughout the term.

4.1.2.5 Assessing against learning outcomes/ objectives
Participants varied widely in their experience of and engagement with assessing against learning outcomes. Some participants implied that the subject learning outcomes were tangential to their teaching and assessment practices. When discussing learning outcomes, participants also described some frustration with learning outcomes about professional skills, suggesting that there was a "mandate" to focus on the technical aspects of the subject. In addition, some participants reported uncertainty about their own interpretation of the learning outcomes. They suggested that taking a team teaching approach can create opportunities for instructors to refine their understandings of the learning outcomes through discussion with fellow instructors.

4.1.2.6 Balancing teaching and assessment
Several participants used language suggesting that teaching practices were separate from assessment practices. These participants reported that time they spent on assessment processes was reducing the time they could be delivering subject content.

4.1.3 Contextual considerations

4.1.3.1 Number of students in a subject
Participants spoke about the relationship between subject enrolment and quality of assessment. The suggestion was that larger student numbers lead to a decrease in the number of opportunities for students to present evidence of their learning. Additionally there was a decrease in the sophistication of the feedback being offered to students. In some cases, team interaction was seen as a corrective factor with the belief that team members can offer each other important and useful feedback in an ongoing manner throughout the term.

4.1.3.2 Number of academic staff involved in delivering a subject
Those participants who delivered their subjects as part of a teaching team report two considerations in terms of assessment in team-based subjects. One consideration was variability among teaching team members in terms of experience with and understanding of the assessment practices within the subject. Where variability is great, the need to train the teaching team added to the overall workload for the subject. Another consideration reported was variability in the interpretation of student evidence within the teaching team. This consideration again addresses one difficulty in outcomes-based teaching in the teaching team context: building a shared understanding of 1) the learning outcomes themselves and 2) what counts as student evidence for mastering a particular outcome.

4.1.3.3 Familiarity with team based pedagogies
This project included participants who taught in dedicated team-based programs using Project Based Learning (PBL) as well as participants employing team-based formats within a more traditional lecture-based curriculum. Some participants in this project were relatively new to teaching team-based subjects while more experienced participants were mentoring instructors who were new to this teaching context. In both cases, participants spoke of the limitations of inexperience with the team-based context on assessment quality.

4.1.3.4 Familiarity with the subject
Similarly, participants reported that relative inexperience with a subject could affect the design and

implementation of assessment items as well as interpretation of the resulting evidence.

These preliminary findings illustrate the complexity of the assessment process for engineering instructors in the team-based setting. The complexities include multiple types of learning to be assessed; an often limited understanding of both the assessment process and the team-based learning environment; and contextual considerations that affect participants' ability to engage in the assessment of student learning in team-based coursework.

4.1.4 The conceptual model

From the 14 themes identified above a conceptual model was developed. This model is shown in Fig. 1, and described in other papers [24].

The research team presented this conceptual model in conference workshops, at symposia, and in informal presentations and conversations [22, 25]. During the process of moving from the conceptual model to the strategic assessment framework, the team derived a number of founding principles to guide the implementation of the framework in varying institutional contexts. These guiding principles were derived from the stage one data and the feedback on the conceptual model.

4.1.5 The guiding principles

The following guiding principles were developed to support the adaptation and implementation of the strategic assessment framework at multiple institutions for the Term 2 2011 pilots:

1. Assessment is a significant 'driver' of student learning, as students' perception of the importance of a given subject activity can be directly related to the weighting the activity is given in the assessment process.
2. Quality of assessment depends on the alignment of learning outcomes, teaching and learning activities, and assessment items.
3. Learning outcomes are the intellectual contract between staff and students and act as the organizing structure for assessment.

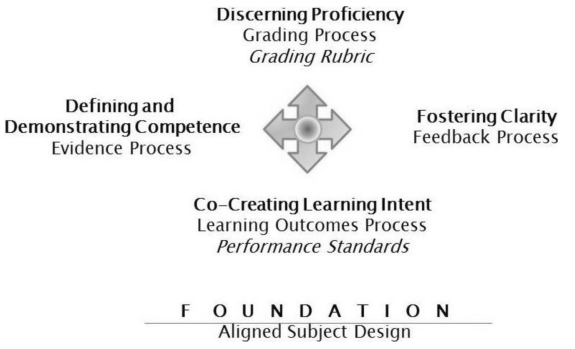

Fig. 1 Conceptual Model.

4. Students' understanding of the connection between learning outcomes, teaching and learning activities, and evidence of learning is developed through ongoing dialogue between students and staff. This ongoing dialogue is vital for optimal student learning and performance.
5. Learning outcomes within a single subject vary in importance and impact, especially when considered within the larger stream of degree-related subjects.
6. Learning activities must provide multiple opportunities for individuals to gather personal evidence of learning against the subject learning outcomes.
7. Team products, such as reports and presentations, are not evidence of individual student learning.
8. Learning teams at the university should differ significantly from working teams in industry in relation to values, practices, and expected outcomes.
9. An individual students' final grade should represent their final state of learning as opposed to indications of learning at various points during the term.

These principles help delimit both evidence of learning and the assessment context itself. Outcomes of this delineation suggest the following. Team products, such as reports and presentations, by themselves provide insufficient evidence of the breadth and depth of an individual student's learning. For this reason, assessment of learning teams at the university should differ significantly from the product driven focus of working teams in industry by valuing individual and team learning over "successful" completion of project assignments. An individual students' final grade should emphasise their final state of learning rather than indications of learning at various points during the term. While feedback may be given for work during the term, assessment of learning should be conducted via a folio of evidence presented at the end of the term.

4.1.6 The strategic framework

The AIT project team's approach in developing the assessment model was framed by the following principles that are informed by Boyer's model of scholarship:

- Assessment is a significant 'driver' of student learning.
- Collaborative learning emphasises not just learning content but also the reacculturation of learners as they enter the community of practice of engineering [36]. It therefore focuses on how the

student's world view changes as this reacculturation takes place, and assessing this change requires holistic assessment.
- The role of assessment in a learner-centred approach like PBL is somewhat different from that in more teacher-centred approaches. Most students (and many staff) see assessment only as a tool for measuring how much they have learned (assessment of learning). In PBL however, there is a strong emphasis on using assessment to support and direct student learning (assessment for learning) [37].

As a group, the project team understood that assessment is a significant 'driver' of student learning. A student's perception of the importance of a given subject activity can be directly related to the weighting the activity is given in the assessment process [38]. At the same time, the team's experience suggests team-based pedagogies, such as project— and problem-based learning, offer a new and perhaps confusing context for students. This is because opportunities for individual students to demonstrate their own learning are often limited when team products form the basis for final grades. In addition, the complexity of team products and the team focus on receiving the highest grade can both limit individual students' input into and control over final version of the product. Using the guiding principles, a strategic assessment framework was then developed from the conceptual model. The fully detailed strategic assessment framework provided the process and tools for academic staff to use. The tools consisted of a standards framework as a guide for preparing summative feedback and a grading rubric to allow grading of an individual against learning outcomes.

The centre of the framework was the development of an evidence based portfolio, created by the individual to demonstrate how she or he had met the learning outcomes for the subject, and to what level. This evidence of achievement was supported and enabled by a standards matrix which was produced by the academic. The matrix identified the range of standards of achievement for each learning outcome, from unacceptable through to excellent, with examples of how that standard might be demonstrated. A grading rubric was then developed to show how a final grade was determined from the portfolio and the relationship of the learning outcomes to the final grade. The framework was then implemented in four pilot trials at the participant institutions in term 2 of 2011.

4.1.7 The pilot

The pilot participants were teaching Engineering subjects, each of which involved a significant team project. The research team delivered an introductory workshop to train the participant academic staff for the Term 2 pilots. While the strategic assessment framework made sense to the research team, the pilot was expected to shed light on "naïve" participant's ability to engage with the framework, and integrate the processes within their individual contexts. Contexts were varied even within an individual institution, where some participants were offering totally project-based and hence team-based subjects, while others were delivering team-based projects as a part of a subject. For this reason, the research team members took a mentoring role during these pilots.

The participants were asked to use a final portfolio of evidence as the assessment item for the project work, and mark with two documents as a common basis for using the framework. The portfolio was to be a compilation of evidence produced by each student individually, and required the student to demonstrate how they, as an individual, had met each of the learning outcomes, and to what level. The documents were a "standards sheet" and a grading rubric. The standards sheet was a matrix of the learning outcomes and the range of expected student outcomes or standards. For each learning outcome, the participants were asked to articulate what would be expected from students for each standard or level of development of that learning outcome. The participants were free to determine how many levels of development would be articulated. Most chose 4, being; unacceptable, acceptable, good, and excellent.

The grading rubric then described how the final grade was determined from the range of evidenced levels of achievement of each of the learning outcomes. It prioritised the learning outcomes according to their relative importance and established expectations for relative mastery of each learning outcome for particular grade levels. Some learning outcomes are vital and students must demonstrate significant levels of competence for these outcomes at the end of term. Other learning outcomes may only need to be demonstrated with basic levels of familiarity. The Grading Rubric is a tool for helping students to understand this prioritization of the learning outcomes as related to levels of the final grade. Offered to students at the beginning of the term, the Grading Rubric reveals the underlying logic of both the subject's contents and assessment framework. The rubric also allows students to make informed choices in terms of where they want to focus their efforts while affording academic staff the opportunity to make more effective grading decisions about individual students learning in teams. In some cases a grade of Pass required all learning outcomes to be met to an acceptable level; in others

the requirement was different. However the participants had to decide on, and communicate to the students the process being used, prior to the start of term.

The pilots were conducted at four institutions with a range of participants, who had varying degrees of experience in education. Each participant was mentored by a member of the project team, and regular meetings were held between the mentor and the participant. At the end of the term, interviews were held with the participants by the project evaluator. The mentors as members of the research team provided their own observations to the project officer as part of the data gathering. This was done as a written reflective document as well as informal interviews.

4.2 Final year projects

The data broadly clustered into four main areas: outcomes, curriculum, assessment and supervision. Of particular interest to this paper is the data in the area of assessment, but some elements of the curriculum area are also of interest.

4.2.1 Assessment

Tasks set for assessment purposes varied across universities but typical product submissions included project plans and proposals, literature reviews and final reports or thesis documents. One School within one university had recently introduced a journal style paper together with supporting documentation as the final submission. Some other assessments students are expected to undertake included presentations, conference style seminars or exhibitions, some of which were large public events. In addition to the valuable industry links forged at such events, there is some evidence to suggest that exhibition enhances the quality of student projects [39].

Weighting for the thesis varied from 40% to 100% of total available marks, and the number of assessment tasks set varied from three to seven. Given that the project subject is usually extended (or comprises of two linked but separate subjects) and culminates in a final submission, there is often close attention to formative assessment. Indeed, improved student engagement and enhanced student interest and learning are possible with strong formative assessment [40, 41]. Some project subjects also included peer and self-assessment.

The marking criteria against which students are assessed are broadly technical (engineering knowledge and skills) and professional (application, communication, teamwork). Some coordinators articulated the challenges posed by the conflation of these criteria, suggesting that seeing the product in isolation to the work conducted or the process undertaken is problematic. Some final year subjects include criteria like diligence, which is arguably effort, whereas others are more tightly focused on product only. Whilst criteria sheets or marking rubrics were widely supported and a sample of one provided in our exemplar practices document, it should be noted that the use of preset criteria is problematic and can result in anomalies [42].

The interview data revealed considerable variation in marking and moderation practices and some coordinators expressed deep concern about supervisor bias and variation. There was also some contention about how to and whether to assess process as well as product. These sub-themes were seen as important but beyond the scope of the guidelines because they fell within the local context. However, the data in this area was extensive and is more fully explored elsewhere [43]. The draft guidelines have been structured around principles of constructive alignment in curriculum design [44], and address how this practice can meet Australian Qualifications Framework (AQF8) learning outcomes. The draft guidelines were distilled from the thematic analysis of the data.

There are two elements from the draft guidelines on assessment that are particularly relevant to this paper. They are that 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.

4.2.2 Curriculum

The documentation and interview transcripts revealed an overwhelming emphasis on self-directed learning within final year project subjects. Final year projects are recognised as culminating opportunities for students to practice and extent what they have learnt in their degree so far. Some universities offered workshop support where students were assisted in research skills such as preparing for and writing a literature review, and these ranges from one-offs to regular (weekly or fortnightly) seminars or classes. Such interventions are supported in the literature, particularly for communication skills for international students where English was not their first language [45]. A couple of universities had introduced stand-alone research methods subjects as prerequisite to the final year project subject and one provided a parallel project management course to assist all students with aspects of project work.

There was not a clear sense in all universities of the ways students are suitably prepared for project work, although literature points to the need for preparedness for project work in the years preceding the FYEP [46, 47]. In our data, it was as if the final year project was a natural culmination to work previously undertaken, but no clear articulation of where students might have, for example, learnt about research. Associated areas were preparation for enrolment and project selection and type. There were also concerns expressed about logistical aspects of sourcing, allocating and administrating projects. Data showed that there was a variety of ways that these tasks were undertaken. For example, in some instances there was an extensive pre-enrolment process where students were carefully matched with advisors and topics. In other cases the process of topic allocation was administrative only with students who signed up first securing the topic. However, all universities invested significant time in preparation for final year project subjects where subject coordinators assume the primary responsibility for the organisation of projects, supervisors and overseeing how projects are allocated to students. Whilst academics will assume a primary role in the organisation of projects, Nepal & Jenkins [46] suggest that student involvement in project scoping and direction is important, and at least one of the universities in our data set had moved towards reducing prescriptive topics in favour for negotiated ones.

The interview data showed and workshop participants confirmed that there were lots of concerns at the institutional level about what constitutes an appropriate project type. Project types across our sample included industry based, design, experimental, multidisciplinary, student initiated, interdisciplinary and supervisor initiated research projects. The value of an industry project as an authentic engineering experience was noted and this is supported in the literature that highlights the value of both industry and multidisciplinary projects [46, 48]. Projects could be individual or group. Workshop participants were in agreement that the type of project and whether it is individual or team based is less important than the degree to which the professional judgement of academics (curriculum designers, advisors, assessors) focused on overarching AQF8 considerations. This means with appropriate curriculum design, quality assessment and supervision, it is potentially possible for any project to enable students to achieve and demonstrate AQF8 outcomes.

4.3 Reflections on the outcomes

While the AIT project was concentrating on team based work demonstrating how the unit outcomes were met, the FYP project was concentrating on how major projects could demonstrate program level outcomes. There are a number of issues that are being mirrored in both projects:

- Application of knowledge
- Purpose
- Authenticity
- Research Skills
- Challenges
- Definitions
- Strengths
- Preparation for Enrolment
- Professional skills
- Technical Knowledge
- Project skills
- Reflective practice
- Projects type

Within the AIT project, each phase of the project revealed important information about the subjective and contextual factors affecting the design and implementation of processes for the effective assessment of individual students. These findings emerged from many sources including research team discussions, formal analysis of interview transcripts, as well as anecdotes told by participants and colleagues during workshops, symposia, and informal conversations.

The evaluation of the trials showed that most of the participants felt that they could adapt the framework to their own teaching even if they hadn't gotten it completely right in this first trial. It was a case of experiential learning for the participants. They had made mistakes and had some successes, and could adapt from those experiences. The critical element that impacted the use of the model was the lecturer's own understanding of the learning outcomes. In nearly every case, the participant struggled to articulate how the learning outcomes could be demonstrated. This was based in a further inability to articulate what they really wanted the students to learn. This issue was identified across the board in the initial interviews with a broad range of staff. In all stages of this project many participants struggled to describe concrete standards by which their learning outcomes could or should be measured. This is a major hurdle for academic institutions to overcome for any genuine outcomes based education. It impacts any form of assessment used. It is also one of the issues that has been observed in the FYP project.

Another critical observation was that staff were focused on content rather than outcomes. The change to outcomes based learning in engineering in Australia has been strongly driven by accreditation processes. The accreditation process requires institutions to demonstrate outcomes rather than

prescribing content. This requirement developed from the 1996 report "Changing the Culture" [5] which identified many issues in engineering education. These issues included content stuffing and over teaching. It appears however from staff reaction that staff are still focused on content rather than outcomes. This is an issue that has been observed by one of the authors when conducting workshops across Australia on accreditation processes. The problem is linked to the problem discussed above, regarding understanding of learning outcomes. If staff are unable to articulate their understanding of learning outcomes, they will revert to what they do understand—content. When they do that, they resort to assessing the final outcome of the project. They resort to assessing the product rather than the learning.

While there is an argument that the product is an important outcome for engineers, there is no guarantee that the product is a representation of the learning. Assigning a moderated grade to the product for each student does not measure what each student has learned. Even when each student in the team has contributed equally and excellently, a focus on one aspect of the project can ensure that only some of the learning outcomes have been met. Assessing the product does not ensure assessment of all the learning outcomes for every team member.

The workload involved in applying this the first time was an issue. It required the participants to ensure that they did have alignment of the learning outcome, teaching and learning activities and the assessment. One of the main pieces of work requiring time was the participant actually articulating the standards of achievement for the learning outcomes. In time poor situations, this is an easy area to ignore. Once again, the difficulty staff had in articulating their understanding of learning outcomes proved a hurdle to using the model. This same hurdle is what drives them to want to assess content rather than outcomes.

Although the model encourages negotiation with students in refining the criteria, standards and rubric, most participants appeared to have difficulty achieving student engagement of this kind. Institutional constraints such as the necessity to have subject outlines (including assessment details) finalized before the start of term made it difficult to make these discussions meaningful.

While the above issues were identified and are important to realise, there were many positive outcomes for the project. The impact on team members has been the movement through a learning process. For different members the impact has been different learnings, but in general, a number of members have reflected on the assessment process itself. To quote one member:

> *"This project has had a profound effect on both the way I understand the assessment process (both generally and assessing individuals in teams) and on helping others to understand assessment and change their practices. Through the project I have deepened my understanding of the important aspects of assessment and how to clearly and effectively assess students, particularly focused on assessing individual learning rather than on team performance."*

Another member has stated that:

> *"this project has opened my eyes to the realisation that people understand assessment in many ways. It doesn't matter how many articles are written on assessment, as individuals, we all put our own slant on what ii means and why we do it."*

A greater understanding of what assessment is and why it is used, leading to reflection on what is the most appropriate assessment process for any particular situation, has been a common impact. The project, through the pilots, gave the team members the opportunity to mentor colleagues in their own institutions. In doing so it also provided the opportunity to use new teaching strategies and develop new classroom activities. A major impact for both team members and participants has been the ability to give grades for work done within a team that is justifiable. As one team member said:

> *"I am now better able to articulate to students their performance and capability. This gives a more justifiable student grading for the subject."*

The project also highlighted, for the participants, the importance of the use of a common language. As in any team situation, it was critical to ensure that a common understanding was developed, as many words have different meanings across institutions, disciplines and applications.

The project outcomes have had an impact on member institutions within the project. For one, the project was critical in gaining full accreditation of their engineering programs using this model of assessment. Accreditation occurred during 2011, and this project provided the evidence and support required for the accreditation. The impact was not just that the model was found appropriate by the accreditation panel, but that participation by the institution in the project, meant that staff outside the project were aware of the basis of the model and were able to discuss and defend its use.

Additionally there are ongoing impacts across the engineering program such as:

- learning outcomes linkage with and contribution to demonstration of graduate capability
- better assessment standards and grading rubrics
- evidence of subject assessment achievement that demonstrates capability attainment

Another partner institution has seen a number of impacts within their engineering program:

- a deeper (and ongoing) engagement with learning outcomes by their teaching staff
- continuing development of professional standards and grading rubrics
- a discussion group has been started with teaching staff beyond those involved in the project
- more discussion across the School with regard to assessment and evidence that demonstrates attainment of competencies

This project will continue to have a major impact on another institution's engineering programs. The understandings and models of assessment were used in the Engineering programs renewal process undertaken to align their programs with the Engineers Australia's Stage 1 Competencies. As the new accreditation process is outcomes-based, requiring instructors to provide evidence of students' attainment of competencies, the assessment models developed during the project were integral to this.

For all participating institutions, there has been a reported link to community through the Engineers Australia accreditation process. All institutions have commented on the very visible link between learning outcomes and the assessment of competencies. This has been a difficult area for many institutions in the accreditation process. This project has informed that process and provided new opportunities to achieve the requirements.

Final year projects are often used to demonstrate how graduates meet both professional and national accrediting agency requirements. In Australia those requirements are Engineers Australia Stage 1 competencies for professional accreditation, and the Australian Qualifications Framework (AQF) for national accreditation. 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 the capstone learning experience for any engineering program. It is the one common experience or subject 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 were two new requirements for Final Year Projects introduced:

1. An AQF8 requirement that it demonstrates research capability.
2. A requirement to satisfy the draft Threshold Learning Outcomes that will be used by Tertiary Education Quality Standards Agency (TEQSA.

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. This project has produced a set of guidelines available to all academics. These guidelines will support them to develop final year projects that are capable of demonstrating the graduate outcomes specified by a range of bodies. The project identified that currently final year projects, at the vast majority of Australian universities, is through the submission of a final thesis report. This is often supported by an oral presentation faculty staff, students and potentially industry members. Both of these forms of delivery concentrate on describing and justifying the artefact or outcome of the project. The guidelines offer academics an opportunity to specifically develop and assess the skills and knowledge development rather than the success of the product.

5. Conclusion

Undergraduate engineering education is becoming increasingly outcomes-driven, as professional organisations seek to define the evolving skillset necessary to join the profession. An important aspect of outcomes based education is identifying and asses-

sing the outcomes of the learning. When engineering students learn in a team based environment, the tendency has been to assess the products rather than the learnings, as traditional assessment methods have been used. The recent Assessment in Teams project considered development of assessment practices for project based subjects that were team based. It sought to determine how an individual who learns in a team based environment could be assessed as an individual. The outcome was a portfolio based assessment item supported by a strategic framework of evidence standards to be met and a grading rubric.

While the assessment framework proved effective, a major finding of this project was a fundamental lack of knowledge in the pilot participants of this project regarding learning outcomes. The result was a difficulty in articulating the meaning of the learning outcomes. Consequently there was difficulty in articulating the standards required to demonstrate those outcomes. An observation was that this was indeed a paradigm change for some. Each of the elements of the framework may have seemed straightforward to many engineering instructors when first described, but the pilot experience suggests that these instructors often lacked the ability to translate these elements into their teaching practice in concrete and constructive ways. These instructors showed a difficulty in moving from a content based approach to an outcomes-based approach in education. For those that did persevere and acknowledge the value in defining their learning outcomes and the standards to demonstrate them, the result was the ability to justify grades and the confidence that they were actually assessing the learning rather than the product.

The second research question asked how the outcomes of final year projects can be used to demonstrate the standards required by various national and international accrediting agencies. As the accrediting agencies use outcomes based assessment, the same issues as the AIT project applied to this question. The interesting point to note is that the Australian accrediting agency requires a portfolio of evidence to support how the program meets the learning outcomes. This is very similar to the solution proposed and trialled in the AIT project. As a PBL based approach, the final year projects require the same approach as other PBL subjects. This would indicate that the portfolio approach is a suitable approach for demonstration of holistic professional approaches.

In many universities in Australia the FYEP is used to demonstrate to the accrediting body (Engineers Australia) that the graduating students have met many of the Stage 1 Competencies that are required of a graduate for the program of study to be accredited. It is now generally accepted that final year projects will be important in demonstrating to what level an engineering program meets the new Australian Quality Framework levels. 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. 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. The guidelines were trialled in Australia in 2014 and the final analysis is being documented. This future work will inform the direction of how these outcomes can demonstrate the standards required by accrediting agencies.

The final research question that the combination of these projects sought to answer was to identify the issues that prevent staff effectively assessing the learning outcomes of individual students. The AIT project 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 issues identified was whether the academic was attempting to assess the product or the learning itself. The AIT project 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.

These two projects together are observing that the concept of Constructive Alignment is not occurring within many project based curricula in the Australian context. PBL in the Australian context needs to consider if project based units are assessing the student learning outcomes or if they are assessing the artefact or product of the project. This paper suggests that assessing the product does not guarantee assessment of the learning of an individual student.

References

1. D. W. Johnson and R. T. Johnson, *Learning together and learning alone: Cooperative, competitive and individualistic learning* (5th ed.), Allyn & Bacon, Boston, 1998.
2. D. Johnson, R. T. Johnson and K. A. Smith, *Active learning: Cooperation in the college classroom*, Interaction Book Company, Edina, MN, 1998.
3. L. Kavanagh, Developing and disseminating TEAM SKILLS capacities using interactive online tools for team formation, learning, assessment and mentoring, http://www.altc.edu.au/carrick/webdav/site/carricksite/users/siteadmin/public/grants_competitive_uq_teamskills_projectsummary_2007.pdf , accessed 6th April 2009.
4. R. King, *Engineers for the Future: Addressing the supply and quantity of Australian engineering graduates for the 21st century,* Australian Council of Engineering Deans, Epping, NSW, 2008.
5. IEAust., *Changing the Culture: Engineering Education into*

the Future, Institution of Engineers, Australia, Canberra, 1996.
6. P. Hager and J. Butler, Two Models of Educational Assessment, *Assessment & Evaluation in Higher Education*, **21**(4), 1996, p. 367.
7. M. G. Rasul, F. Nouwens, F. Martin and C. Greensill, Benchmarking in assessment of final year engineering projects, *CQUniversity Internal learning and Teaching Report*, Australia, 2010.
8. J. Jawitz, S. Shay and R. Moore, Management and assessment of final year projects in engineering, *International Journal of Engineering Education*, **18**(4), 2002, pp. 472–478.
9. D. J. Oehlers, Sequential assessment of engineering design projects at university level, *European Journal of Engineering Education*, **31**(4), 2006, pp. 487–495.
10. D. Tribe and A. Tribe, Assessing law students: lectures attitude and practices, *Assessment and Evaluation in Higher Education*, **13**(3), 1988, pp. 83–93.
11. F. Webster, D. Pepper and A. Jenkins, Assessing the undergraduate dissertation, *Assessment and Evaluation in Higher Education*, **25**(1), 2000, pp. 71–80.
12. P. J. Armstrong, R. J. Kee, R. G. Kenny and G. Cunningham, A CDIO approach to the final year capstone, *Paper presented at the 1st Annual CDIO Conference*, Queen's University, Kingston, Ontario Canada 7–8 June, 2005.
13. A. S. Blicblau, 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,* Auckland, New Zealand, 10–13 December 2006.
14. R. H. A. Seidel, J. D. Tedford and M. A. Islam, 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,* Auckland, New Zealand, 10–13 December 2006.
15. R. Kuisma, Portfolio assessment of an undergraduate group project, *Assessment & Evaluation in Higher Education*, **32**(5), 2007, pp. 557–569.
16. J. E. Mills, 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,* Melbourne, Australia, 9–13 December 2007.
17. M. Beckerleg and J. Collins, Producing research from undergraduate projects. In H. Sondergaard & R. Hadgraft (Eds.), *Proceedings of the 18th Conference of the Australian Association for Engineering Education*, Melbourne, Australia 9–13 December 2007.
18. M. G. Rasul, F. Nouwens, F. Martin, C. Greensill, D. Singh, C. Kestell and R. Hadgraft, 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,* Adelaide, Australia 6–9 December 2009.
19. S. Cochrane, S. Goh and H. Ku, 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,* Adelaide, Australia, 6–9 December 2009.
20. E. Valderrama, M. Rullan, F. Sanchez, J. Pons, C. Mans, F. Gine, L. Jimenez and E. Peig, E, Guidelines for the final year project assessment in engineering, *The 39th ASEE/IEEE Frontiers in Education Conference,* San Antonio, Texas, 2009, Session M2J.
21. M. G. Rasul, F. Nouwens, R. Swift, F. Martin and C. Greensill, 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,* IGI Global, USA. 2012, pp. 80–104.
22. M. Eliot, P. Howard, F. Nouwens, A. Stojcevski, L. Mann, J. K. Prpic, R. Gabb, A. Venkatesan and A. Kolmos, Developing a Conceptual Model for the Effective Assessment of Individual Student Learning in Team-Based Subjects, *Australasian Journal of Engineering Education*, **18(**1), 2012, pp. 105–112.
23. P. Howard and M. Eliot, 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 December 2012.
24. P. Howard and M. Eliot, *A Strategic Framework: Assessing Individual Student Learning In Team-Based Subjects*, Proceedings of 3rd International Research Symposium on Problem-Based Learning. Coventry, England, 2011.
25. M. Eliot and P. Howard, Instructor's considerations for assessing individual students' learning in team-based coursework, *Proceedings of 2011 Australasian Association for Engineering Education Annual Conference*, Fremantle, Australia, 2011.
26. Engineers Australia, G*O2 rev2: Engineers Australia National Generic Competency Standards—Stage 1 Competency Standards for Professional Engineers,* Engineers Australia, Canberra, 2008.
27. C. Baillie and E. P. Douglas, Confusions and Conventions: Qualitative Research in Engineering Education, *Journal of Engineering Education*, **103**(1), 2014, pp. 1–7.
28. A. L. Brown, Design experiments: Theoretical and methodological challenges in creating complex interventions, *Journal of the Learning Sciences*, **2**(2), 1992, pp. 141–178.
29. A. Collins, D. Joseph and K. Bielaczyc, Design Research: Theoretical and Methodological Issues, *Journal of the Learning Sciences*, **13**(1), 2004, pp. 15–42.
30. A. Strauss and J. Corbin, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.* Sage, London, 1998.
31. K. Charmaz, *Constructing Grounded Theory*, Sage, Thousand Oaks, CA. 2006.
32. R. M. Felder and R. G. Hadgraft, Educational practice and educational research in engineering: partners, antagonists, or ships passing in the night?, *Journal of Engineering Education*, **102**(3), 2013, pp. 339–345.
33. E. L. Boyer, *Scholarship reconsidered: Priorities of the professoriate,* (2nd ed.) San Francisco: Jossey-Bass, 1997.
34. R. Boyatzis, *Transforming Qualitative Information: Thematic Analysis and Code Development*, Thousand Oaks, CA: Sage Publications, 1998.
35. J. Biggs, *Teaching for Quality Learning at University*, SRHE and Open University Press, Buckingham, 1999.
36. K. Bruffee, *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge*, Baltimore: Johns Hopkins University Press, 1999.
37. M. G. Weimer, *Learner-Centred Teaching: Five key changes to practice*, San Francisco: Jossey-Bass, 2002.
38. P. Black and D. William, Assessment and classroom learning, *Assessment in Education: Principles, Policy & Practice*, **5**(1), 1998, pp. 7–74.
39. S. A. C. Kar, N. Mukahar, N. I. M. Enzai, S. S. Rais and S. M. Sabri, Enhancing final year project through exhibition and competition, *World Applied Sciences Journal*, **23**, 2013, pp. 8–11.
40. A. Gardner and K. Willey, Student participation in and perceptions of regular formative assessment activities, *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria.
41. H. Jiao and N. Brown, Providing the right feedback to the right students: applying an innovative e-assessment system in engineering education. *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria.
42. R. Sadler, Indeterminacy in the use of preset criteria for assessment and grading, *Assessment and Evaluation in Higher Education*, April 2008, pp. 1–20.
43. J. Lawson, M. Rasul, P. Howard and F. Martin, Getting it right: Assessment tasks and marking for capstone project courses. Paper presented at *Capstone Design Conference*, 2–4 June 2014, Columbus, Ohio.
44. J. Biggs, Enhancing teaching through constructive alignment. *Higher Education*, **32**, 1996, pp. 1–18.
45. A. S. Blicblau and K. Dini, Intervention in engineering students' final year capstone research projects to enhance

their written, oral and presentation skills, *International Journal of Engineering Pedagogy*, **2**(3), 2012, pp. 11–18.
46. D. Hogan, Uncanned learning through an industry based final year project—food for thought, *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria.
47. K. P. Nepal and G. A. Jenkins, Blended project-based learning and traditional lecture-tutorial-based approaches in engineering design courses, *Proceedings of the 2011 AAEE Conference*, Freemantle, Western Australia.
48. M. Bramhall, C. Short, A. Hoque, J. Blohm, L. Campbell and A. Young, A. Multi-disciplinary and cross year mentoring: the development of an eco-house and a sustainable marriage! *Proceedings of the 2011 AAEE Conference*, Fremantle, Western Australia.

Prue Howard is a senior lecturer, Convenor of the Future Engineering Education Directions (FEED) scholarship group and Deputy Director of the Learning, Teaching Education Research Centre at Central Queensland University. She is also President of the Australasian Association for Engineering Education and former Editor of the Australasian Journal for Engineering Education. Prue has received National Awards in the areas of Women in Engineering and Curriculum Innovation, as well as having received the University's Vice-Chancellor's Award for Quality Teaching and the Deans Award for Teaching Excellence twice.

Matt Eliot currently serves as Head of Noosa Campus at Central Queensland University on Queensland's Sunshine Coast. His current research areas include the values and morality inherent in engineering education, student aggression toward academic and professional staff across disciplines in universities, and the upskilling of academic staff around both education research and the evaluation of their teaching and learning activities.

Mohammad Rasul is an Associate Professor at the School of Engineering and Technology, Central Queensland University, is well experienced in design, development and assessment of FYEPs and has contributed significantly to the operation of FYEPs in undergraduate engineering programs at Central Queensland University.

Fons Nouwens is a retired Lecturer in Civil Engineering. He has extensive experience in instructional design and curriculum development and provides curriculum development support to academic staff in engineering undergraduate programs at CQUniversity. He has coordinated FYEP courses at CQUniversity, and supervises FYEP students.

Justine Lawson is a Senior Research Officer at the School of Engineering and Technology, Central Queensland University. She has significant academic and professional experience in the areas of assessment and teaching and learning. She has wide experience in research projects and has both participated in and led interdisciplinary research projects and partnerships across a number of institutions.