

# An assessment model for individuals within PBL

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## Abstract

The inherent complexity of team-based learning environments creates ambiguity for academic staff and students alike in terms of learning goals and the production of evidence of individual student learning. This five-institution research project developed a conceptual model for effective assessment of individual student learning in this highly collaborative setting. This model was then workshopped and piloted at 4 institutions within Australia. This paper reports on the research design of this project, and discusses the outcomes of the pilot use of the model, as well as identifying issues for ongoing research.

*Keywords: Project Based Learning, assessment, rubrics, constructive alignment, learning outcomes*

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## 1. Introduction

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, 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 been 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, which 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. As assessment drives behaviour, the desire for higher grades influences the team dynamics resulting in an emphasis on project outcomes rather than individual learning, potentially degrading collaborative learning (Johnson and Johnson 1998, Johnson, Johnson and Smith 1998)

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. The majority of engineering academics and industry professionals understand and are more comfortable with quantitative assessment methods. 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. The recent ALTC-supported project "Engineers for the Future" (King, 2008) recommends the development of best-practice engineering education to promote student learning and deliver intended graduate outcomes. This project follows the 1996 report "Changing the Culture (IEAust, 1996), which first highlighted the need for change to an outcomes-based engineering education system in Australia. Experience with accreditation teams shows their mistrust of qualitative assessment, with 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.

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 should capture both technical/scientific knowledge, as well as those higher order processes that are the hallmark of team-based project-oriented subjects – higher order processes such as design thinking, communication, and teamwork.

This paper gives an overview of the entire project which took two years. The early stages of the project have been reported on in publications such as Eliot and Howard et al 2012, Eliot and Howard 2011, and Howard and Eliot 2011. 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.

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## 2. Methodology and methods

This research and development project is founded on a synthesis of design research (Brown, 1992; Collins, Joseph, and Bielaczyc, 2004) and Grounded Theory inquiry (Strauss and Corbin, 1998; Charmaz, 2006). 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 our case, 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.

Drawing from these methodological traditions, the research team has pursued the following activities:

1. Conducted interviews and focus groups with academic staff and students at the five member institutions.
2. Analysed the interview transcripts using qualitative data analysis methods to reveal current assessment practices, common and unique understandings of the purpose of assessment, and perceived challenges or limitations.
3. Constructed a conceptual model illustrating the essential features of effective assessment of individual student learning in the team-based, project-based setting.
4. Implemented a pilot study of the strategic assessment framework based on the conceptual model at the Australian member institutions to explore the feasibility and relevance of the model itself.

The method was based on a list of three initial assumption articulated by the project team:

- Assessment is a significant ‘driver’ of student learning.
- Collaborative learning emphasizes not just learning content but also the reacculturation of learners as they enter the community of practice of engineering (Bruffee, 1999). It therefore focuses on how the world view of students 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. While most students (and many staff) see assessment only as a tool for measuring how much they have learned (assessment of learning), in PBL there is a strong emphasis on using assessment to support and direct student learning (assessment for learning) (Weimer, 2002).

As described in Howard & Eliot, (2011), a conceptual framework was developed and articulated. This model is shown in Figure 1 below.

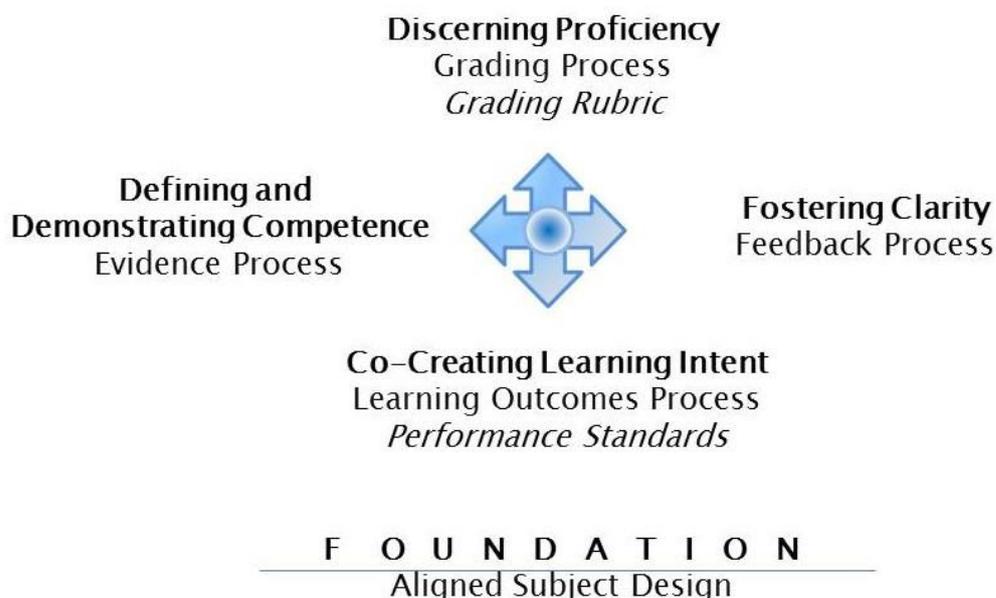


Figure 1. Conceptual Model

The research team presented this conceptual model in conference workshops, at symposia, and in informal presentations and conversations (Eliot, M. and Howard, P., 2011 and Eliot, Howard, et al 2012). During the process of moving from the conceptual model to the strategic assessment framework, we derived a number of founding principles to guide the implementation of the framework in varying institutional contexts.

As a group, we understood that assessment is a significant ‘driver’ of student learning as 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 (Black and William, 1998). At the same time, our experience suggests team-based pedagogies, such as project- and problem-based learning, offer a new and perhaps confusing context for students 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

### 3. The guiding principles

Reflecting on these and similar observations, as well as the preliminary data analysis findings, (presented in Eliot Howard et al, 2012) the research team developed the following principles 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.
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.

The model was then implemented in four pilot trials at the participant institutions in term 2 of 2012.

### 4. 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. 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.

## **5. Outcomes**

Each phase of this multi-phase project revealed important information about the subjective and contextual factors affecting the design and implementation of processes for the effective assessment of individual students in team-based project-oriented classes. 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 following comments on the outcomes of the pilots, is based on the reflective observations of the mentors at the end of the project. Most of the participants in the trial felt that they could adapt the framework or elements of the framework and its associated tools 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.

Some of the issues that were observed were:

- 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.
- 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.

The specific observations were broken down into three main areas, content, process and context.

### *5.1. Content Considerations*

There were a range of skills considered.

#### *5.1.1. 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.

#### *5.1.2. Assessing professional knowledge and skills*

In addition to technical knowledge and skills, participants reported taking professional knowledge and skills into consideration, 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.

#### *5.1.3. Assessing broad understanding*

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 and do not engage substantively with other aspects of the project which are vital to their overall learning. 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.

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 and using 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.

#### *5.1.4. Assessing design thinking*

For the purposes of this paper, design thinking is being defined as the chain of reasoning within individuals and team 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 with an emphasis on exploring an individual student's understanding of key decision points in the design process.

### *5.2. Process Considerations*

There were several processes considered..

#### *5.2.1. 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.

#### *5.2.2. 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 understand team "health", participants used direct observation, observation in supervisory meetings, and peer assessment to look for positive team interaction as well as power imbalances and significant differences in contribution.

#### *5.2.3. Assessing international students*

Participants expressed concerns about assessing international students within their subjects in terms of 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 instructors holding international students to less rigorous standards to instructors 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.

#### *5.2.4. Use of formative assessment opportunities*

Many participants in this project recognised that formative assessment opportunities offered at strategic points across the term 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.

#### *5.2.5. 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, suggesting that taking a team teaching approach can create opportunities for instructors to refine their understandings of the learning outcomes through discussion with fellow instructors.

#### *5.2.6. 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.

### *5.3. Contextual Considerations*

There were a range of contexts considered..

#### *5.3.1. Number of students in a subject*

Participants spoke about the relationship between subject enrolment and quality of assessment, suggesting that larger student numbers lead to both a decrease in the number of opportunities for students to present evidence of their learning and 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.

#### *5.3.2. 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 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.

#### *5.3.3. 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.

#### *5.3.4. 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: 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.

## **6. Conclusions**

AIN this project, researchers from five tertiary institutions investigated current practices for assessing individual student learning in team-based undergraduate engineering coursework and from this investigation constructed a strategic framework which effectively assessed individual student learning in the team context. Undergraduate engineering education is becoming increasingly outcomes-driven, as professional organisations seek to define the evolving skillset necessary to join the profession. 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 the functions and the affordances of learning outcomes in the engineering curriculum.

This complexity calls for greater theoretical understanding of this assessment context, including types of teaching practices that can result in greater clarity for instructors and students alike. The main observation was that this was indeed a paradigm change for some. The project's tools help them to formulate their goals but further training in techniques such as constructive alignment and greater familiarity with educational principles generally in the participating academics was needed to make sure the tools are implemented effectively. Each of the elements of the framework may have seemed straightforward to many engineering instructors when first described, but our pilot experience suggests that these instructors often lacked the ability to translate these elements into their teaching practice in concrete and constructive ways.

The findings to date suggest that each of the elements of the model may have seemed straightforward to many engineering instructors when first described, but 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.

A full report of the findings can be seen in the final project report (Howard and Eliot, 2012)

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