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A framework for Assessing Individuals who Learn in a Team Environment

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BACKGROUND

Grading individual students in teams 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 context. However, within engineering team-based project-oriented subjects, individuals have traditionally been assigned a grade heavily influenced by the team's project deliverables rather than their individual efforts.

PURPOSE

The aim of this project was to develop and pilot an assessment model which captures both technical/scientific knowledge as well as those higher order processes which are the hallmark of team-based project-oriented subjects – higher order processes such as design thinking, communication, and teamwork.

DESIGN/METHOD

In 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. This framework was then introduced to participants as a model, and a number of pilot trials of the model were conducted at the participant institutions.

RESULTS

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, and anecdotes told by participants and colleagues during workshops, symposia, and informal conversations. The resulting model is composed of five processes which, when taken together, demonstrate the team's understanding of the fundamental elements involved in the effective assessment of individual students in team-based learning environments.

CONCLUSIONS

The findings to date suggest that each of the elements of the framework 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. 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. Additionally the outcomes suggest that the team-based project-oriented learning environment itself presents a level of complexity in terms of assessment that surpasses the traditional lecture/tutorial format.

KEYWORDS

Assessment, individuals, team based, portfolios, engineering.

Introduction

Grading individual students in teams 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 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 resulting in an emphasis on project outcomes rather than individual learning, potentially degrading collaborative learning (Johnson and Johnson, 1998; Johnson, Johnson, and Smith, 1998).

The recent ALTC-supported project "Engineers for the Future" (King, 2008) recommended the development of best-practice engineering education to promote student learning and deliver intended graduate outcomes. This project followed the 1996 report "Changing the Culture (IEAust., 1996), which first highlighted the need for change to an outcomes-based engineering education system in Australia. Implementing changes to student learning and graduate outcomes have since resulted in a greater emphasis on team-based projects. 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).

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. These contrast with the quantitative assessment methods generally used in engineering subjects that make up a program of study to 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. 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. This was a major challenge to the acceptance, accreditation and implementation of PBL-based assessment of individuals in teams. It was also an issue for all engineering programs, which must demonstrate graduate outcomes from complex tasks such as final-year design and research projects. The requirement for an outcomes based education approach means 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) and instead focus on an individual student's learning.

The Project

Project teams are ubiquitous in professional engineering and team-based subjects offer a perfect opportunity to prepare undergraduate engineering students for this professional context. These students may learn in teams, but they are assigned grades as individuals. Within engineering team-based projects, individuals are often assigned a grade heavily influenced by the team's project deliverables. Yet a student's grade should be a direct reflection of what she or he has learned as an individual, related to the specific learning outcomes associated with that subject. How then should an instructor proceed with designing and implementing assessment in her team-based subject in ways that support collaboration within student teams while also revealing the rich range of learning that is available for individual students?

Instructors have a confusing variety of assessment methods available for the team-based setting. Some advocate self- and peer- assessment as one approach for determining the final grade for individual students. This group of methods can reveal relative engagement by students within the team, even though it is also fraught with issues such as social desirability bias (Falchikov and Goldfinch, 2000). Internationally, portfolio assessment has been adopted as a valid approach to assessing individual student learning in a range of engineering institutions (Cress and McCullough-Cress, 1995; Jorgensen and Howard, 2005; Mourtos, 1997). Narrative evidence (such as reflective journals and oral examinations), in combination with more traditional assessment activities (such as invigilated exams), may allow for a more nuanced view of an individual student's learning in team-based subjects, particularly in meeting institutional and national academic standards, but only if instructors understand both these methods and what counts as evidence for meeting these academic standards (Michigan Engineering, 2010; Leydens, Moskal, and Palevich, 2004; Felder and Brent, 2003; Williams, 2002; Olds and Miller, 1997).

The aim of this project was to develop an assessment model where the team projects are the learning environment and the portfolios or oral examinations are the individual's summative assessment—a model of assessment that has been accepted in many disciplines that are qualitative in nature, such as education and human factors. In engineering education, portfolio assessment has been used in a range of institutions internationally (Cress and McCullough-Cress, 1995; Jorgensen and Howard, 2005; Mourtos,1997; Payne et al.,1997). However, these methods of assessment were viewed with scepticism in engineering programs within Australia. Such models have been the subject of teaching and learning research (Michigan Engineering, 2012), but the assessment models and grading decisions used must be capable of withstanding external scrutiny, that is, they must be accepted as valid by the accreditation body for engineering programs in Australia to embed these assessment models within institutional practice.

Initial Assumptions

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 (Biggs and Tang, 2007).

The project team's approach in developing the assessment model was therefore framed by the following principles that are informed by Boyer's model of scholarship (Boyer, 1997):

- 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).

The Project Process

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 theory of effective assessment of individual students' learning in team-based pedagogies such as PBL. Based on these consideration, the research team then constructed a conceptual model for assessing individual student learning in team-based learning environments, also taking into account relevant literature sources and the team's own professional experience in this context. After workshopping this conceptual model in a variety of professional contexts, the research team then developed a set of guiding principles for effective individual assessment in the team-based environment and instantiated these principles into a workable strategic assessment framework, which was piloted in undergraduate engineering courses at four Australian universities in Term 2 of 2011. The purpose of these pilots was to test the construct validity of the conceptual framework and to explore issues around its implementation. A full description of the process that was used in this project has been reported earlier in Eliot and Howard, 2011, and Eliot et al 2012.

Initial Research

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, and anecdotes told by participants and colleagues during workshops, symposia, and informal conversations. As reported previously, (Eliot and Howard, 2011, and Eliot et al 2012) there were 14 themes that emerged.

These preliminary findings illustrated the complexity of the assessment process for engineering instructors in the team-based setting: multiple types of learning to be assessed, 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.

These considerations also highlighted the complexity of assessment in this environment by describing the types of learning possible in most team-based subjects:

- Technical knowledge and skills
- Professional knowledge and skills
    - Including teamwork, professional communication, and project management
- Design thinking

The project members in this study recognized that these varying types of learning called for differing assessment methods to capture the breadth and depth of an individual student's learning in each of these areas. For example, technical knowledge has traditionally been assessed by quantitative methods ranging from a class quiz to an invigilated exam. Professional skills and design thinking, on the other hand, may require narrative methods such as oral examinations or reflective journals to reveal students' nuanced understanding underlying these types of learning.

One recurrent theme was the discussion of outcomes-based teaching and assessing. Participants expressed a number of considerations about learning outcomes and their use in teaching activities, ranging from lack of knowledge about outcomes-based teaching to concerns about the impact of outcomes-based teaching and learning on their ability to focus on delivering subject content.

Strategic Assessment Conceptual Model

The Strategic Assessment model was constructed from a combination of the findings from the participant interviews, reflection on the scholarly literature on assessment in the team-based, project-oriented setting, and the professional experience of the research team itself. Figure 1 illustrates this assessment model.

The Strategic Assessment Conceptual Model is composed of five basic processes. When taken together, they demonstrate our understanding of the fundamental elements involved in the effective assessment of individual students in team-based learning environments.

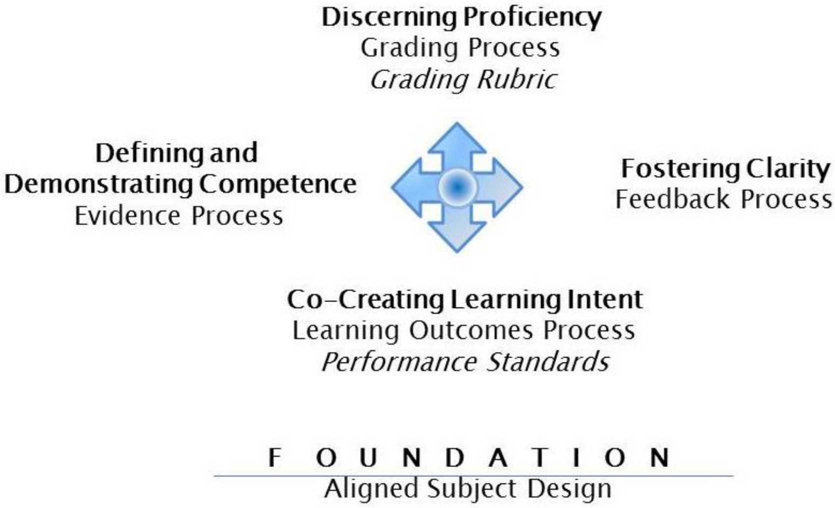

Figure 1. Strategic Assessment Conceptual Model

The arrows in Figure 1 are meant to indicate the interdependence of each of these processes. The detail of this model has been described in previous papers (Eliot and Howard, 2011, and Eliot et al 2012).

The Guiding Principles

The research team presented this conceptual model in conference workshops, at symposia, and in informal presentations and conversations. 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

Reflecting on these and similar observations, as well as the preliminary data analysis findings, 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.

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.

Outcomes

The following discussion of 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 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.

Conclusion

In 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 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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