Reflections on assessment: comparison of assessment processes for postgraduate Engineering management courses

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Structured abstract

BACKGROUND
The University of Southern Queensland conducts a number of postgraduate engineering management courses under the Master of Advanced Engineering program. The courses cover topics such as asset management, facilities management, risk management, innovation management, technology development, technological management and its impact, and technology management practice. A course in advanced project management is under development. The current method of assessment for these courses consists either of one or more assignments plus an examination, or wholly by assignment. Ideally, their assessment should ideally reflect professional industry requirements.

PURPOSE
To compare assessment in selected courses for which the author is currently examiner, with a view to determining how well they meet authentic industry requirements, in order to both improve existing postgraduate professional engineering management courses and inform assessment of the advanced engineering project management course currently being developed, along with future postgraduate professional engineering courses.

DESIGN/METHOD
The review approach was to:

- Select three courses for review, each with a different assessment approach to review current course assessment requirements. One of these courses is *Asset Management in an Engineering Environment,* discussed in a previous paper,
- Review professional engineering requirements for Engineers Australia.
- Using the author as participant investigator, compare assessment for each of the selected courses against good authentic course assessment and each other.
- Reflect on the findings and develop conclusions with respect to course assessment.

RESULTS
The research is expected to result in better understanding of the way in which assessment in postgraduate engineering management courses is conducted, provide guidelines for more industry relevant assessment, and inform assessment for future courses of this nature. To date, evaluation of the assessment of the Asset Management in an Engineering Environment course has resulted in an improved, more authentic assignment and an improved examination that better addresses industry and professional requirements.

CONCLUSIONS
Conclusions are developed with respect to reflection on the different modes of assessment for the three courses selected for this study. These conclusions have resulted in changes in the assessment of one course and have informed assessment procedures for an advanced engineering project management course currently under development. Future evaluation and piloting of authentic assessment are discussed.

KEYWORDS
Engineering; management; assessment; authentic; industry

Introduction

In order to meet industry requirements with respect to experienced professional engineering knowledge and skills, the University of Southern Queensland offers a Master of Advanced Engineering program that includes Engineering Management and Engineering Project Management majors. The core courses in the Master of Advanced Engineering are *ENG8103 Management of Technological Risk* (University of Southern Queensland 2013a) and *ENG8104 Asset Management in an Engineering Environment* (University of Southern Queensland 2013b). Other courses include *ENG8011 Assessment of Future Specialist Technology* (University of Southern Queensland 2013c), which is offered in the Engineering Management major. The summative assessment process used in each of these three courses is different.

The assessment process in each of these courses has been reviewed and compared, with a view to evaluating how well each of them meets the requirements of good assessment, particularly with respect to authentic professional practice. The results have the potential to inform the assessment of both existing and new courses in the Master of Advanced Engineering, and other advanced coursework educational programs, both at the University of Southern Queensland and elsewhere. This evaluation has been undertaken by the author, who taught these courses in 2013, and in the past has either been examiner or moderator of each of them, as participant investigator.

The principal research questions to be addressed in the evaluation process were:

- How well does the summative assessment in each of these courses meet authentic industry requirements?
- Can this assessment be improved, in these courses and in future courses?

Principles of Good Course Assessment

According to Boud (1998), the two key purposes of assessment are to certify and prompt learning. Good assessment tends to be criterion-referenced (Connoley, 2004) and meet the principles of constructive alignment (Biggs, 1999, p. 64; Gulikers et al,. 2004). Quality assessment should also support the interrelated objectives of guiding and encouraging effective approaches to learning, validly and reliably measuring expected learning outcomes, and defining and protecting academic standards (James, McInnis and Devlin (2002).

According to Connoley (2004), good criterion-referenced assessment requires clarity about what learners should be learning in terms of qualities or performance criteria, and assessment tasks that advise assessors with respect to how well learners meet learning criteria. This process commences with setting learning objectives. Other considerations in good assessment include challenging learners to achieve deep learning, or going below the surface of the study material to understand its meaning (Biggs, 2001). Such assessment should not only be aligned with course objectives and instruction, but also provide challenging, realistic tasks that motivate learners to meet higher order learning objectives.

Authentic Assessment

One of the key challenges in teaching professional learners is to cross the gap between teaching and professional practice. Authentic assessment (for example, Gulikers *et al.*, 2004) is one approach to achieving this goal. It also is claimed to meet the principles of constructive alignment between instruction, learning and assessment.

Authentic assessment may be defined as “an assessment that requires learners to demonstrate the same competencies, or combinations of knowledge, skills, and attitudes that they need to apply in the criterion situation in professional life” (Gulikers *et al.*, 2004). Because assessment as normally applied tends to make evaluative judgments and therefore is an indicator of learning (Chittenden, 1991) rather than a definitive statement about the

attainment of learning, making it as realistic or authentic as possible is likely to considerably improve its ability to measure actual learner performance

Gulikers *et al.* (2004) observe that while opinions differ on what constitutes authentic assessment, it is clear that it is a form of performance assessment and accordingly links closely with criterion-referenced assessment. They consider authentic assessment from a competency development point of view. Thus, to positively influence learning, authentic assessment should be aligned to academic instruction, and require learners to demonstrate competencies in a situation resembling professional practice. It can be argued that the two most important reasons for choosing authentic assessment are construct validity (related to whether an assessment measures what it should measure) and consequential validity (which describes the intended and unintended effects of assessment of instruction on teaching) (Gulikers *et al.*, 2004). Authentic assessment would also be expected to have reliability (the degree to which test scores are free from errors of measurement - American Psychological Association as cited in Killen, 2003) and be fair. It therefore meets a number of requirements of good assessment. With its strong practical performance focus, it would accordingly be expected to assess the depth of learning of engineers in professionally oriented courses.

Gulikers *et al.* (2004) relate authentic assessment to authentic instruction, and define it under following the five elements, each of which is listed with its key attributes below:

1. Task – meaningfulness, typicality and relevance to learner; degree of ownership of problem and solution space; degree of complexity.
2. Physical context – similarity to professional space; availability of professional resources; similarity to professional time frame.
3. Social context – similarity to the social context of professional practice.
4. Result/form – demonstration of competence; presentation to others; multiple indicators of learning.
5. Criteria – based on criteria used in professional practice; related to realistic products/processes; transparent and explicit; criterion-referenced leading to profile score.

Ideally, because the courses selected for this study are designed to enhance the professional skills and competencies of their students, their assessment should as closely as possible mirror what would be expected in real professional practice. For example, learners studying *Asset Management in an Engineering Environment* should be able to undertake the complex task of optimising the asset life cycle of an asset to meet stakeholder performance requirements in a safe and environmentally sound manner through a range of activities like planning, investment financing, engineering, operations, maintenance, rehabilitation and replacement (Lutchman (2006, p. 18). A similar argument could be mounted for learners studying *Management of Technological Risk*, who would be expected to understand risk management standards, understand basic probability theory, and apply risk management to managing projects and processes. Similarly, learners studying *Assessment of Future Specialist Technology* require an understanding of the innovation process (Rogers, 2003), as well as of the implications and applicability of new technological developments.

As engineers are required to undertake a range of professional tasks and responsibilities in a given physical and social context to required and measureable levels of competency, the elements of authentic assessment as defined by Gulikers *et al.* (2004) are basically suitable for assessing learner achievement of objectives in the three professional courses selected for this research. It is, however, considered that these elements require enhancement if they are to better measure the changing and increasing demands placed on engineers in their professional life. This point is discussed in the next section.

Professional engineering requirements

There is an increasing requirement by professional organisations for ethical practice in their members. For example, the Engineers Australia Code of Ethics (2010) defines the values and principles that shape the decisions made in engineering practice. In particular,

professional engineers are required to demonstrate integrity, practise competently, exercise leadership and promote sustainability. Engineers Australia also recognises two levels of competency – graduate engineers and experienced professional engineers, who have to demonstrate that through their professional experience they have met particular competency requirements, which include, as well as basic engineering competencies, competencies in developing safe and sustainable solutions, engaging with the community and stakeholders, communication, risk assessment, and creativity and innovation (Engineers Australia, 2012).

Engineers are also subject to a number of emerging areas, such as efficient energy management, disaster management and resilience, which is the capacity of a system to absorb disturbance and reorganise so as to retain essentially the same function, structure and feedbacks (Walker and Salt, 2012, p.3). Thus, engineers are required to not only practice ethically and sustainably, but also be creative, innovative, manage risks, and engage with the community and stakeholders. Therefore, given the strong requirements for professional engineers to not only achieve competencies required to practice in their industry, but also meet a range of other professional engineering requirements, the element *professional skills* has been added by the author to the authentic assessment framework proposed by Gulikers e*t al.* (2004), in order to improve the fit of course assessment in the selected three courses to authentic assessment criteria. The attributes (or subsets) of *professional skills* are sustainability and resilience, risk and safety, and other professional issues.

Methodology for Evaluation of Authentic Assessment

In order to evaluate the assessment in the selected three courses from the point of view of the authentic assessment framework developed by Gulikers *et al.* (2004) (as modified by adding the *professional skills* element), a methodology based on that of Owen (2007) for program evaluation was used. Owen (2007, p.1) states that evaluation may be seen as a process of knowledge production, and that it rests on rigorous empirical enquiry. He defines three steps in the evaluation process: developing an evaluation plan; implementing an evaluation design to produce findings; and disseminating findings to interested audiences (Owen, 2007, p.63).

The author chose to use an interactive approach, based on the assumption that people with a direct vested interest in interventions (such as the author) should also control the evaluation of these interventions, in order to improve a program that is already being delivered (Owen, 2007, p. 39). In this process, the author acted as participant investigator, in which the questions asked focused on what happened in the assessment, what was working well and not working well, how learners were affected by the assessment, how the assessment met the individual goals and needs of learners, and how it could be improved (Owen, 2007, p. 93).

Evaluation of Selected Courses for Authentic Assessment

Overview

The methodology described above was applied, by the author, to evaluate current assessment for each of the three selected courses against good authentic assessment. This process was supplemented by a comparison of examination grades in the past two offers of each course. The author's experience in writing two of the courses and delivering all of them were major inputs into the evaluation. Where available and relevant, learner comments were also used as input. In comparing the assessment with the elements of authentic assessment, the author used a five point Likert scale, which was designed to rate the fit of the each assessment item to each of the six selected authentic assessment elements. A rating of 1 was given to a very poor fit; a rating of 2 to a poor fit; a rating of 3 to an acceptable fit; a rating of 4 to a good fit; and a rating of 5 to a very good to excellent fit.

In this process, each element of authentic assessment was divided into its attributes, against which each assessment item was firstly rated individually, and then aggregated to the value shown in the tables for the element for that assessment item. For example, “task” was subdivided into its attributes of meaningfulness, typicality and relevance in the student’s eyes; degree of ownership of problem and solution space; and degree of complexity. The individual attribute ratings for a given assessment item were then aggregated to the final rating estimate for “task.” In addition, the score for each assessment item for a particular course was weighted by the percentage of marks given to it to calculate a weighted average score for the course as a whole against a particular authentic assessment element.

An evaluation of authentic assessment for ENG8104 *Asset Management in an Engineering Environment* using the above process has been previously discussed in some detail (Thorpe, 2012). This course is included both for completion and to briefly discuss changes in this course as a result of this its previous evaluation.

ENG8103 Management of Technological Risk

ENG8103 Management of Technological Risk focuses on the prediction and assessment of risks in technological systems. Learner objectives may be summarised as assessing risks; evaluating risk consequence and likelihood; selecting, justifying and applying risk treatment strategies; and appraising and utilising tools and techniques to reduce and manage risks.

Teaching is divided into risk management and the application of theory to risks and project and process management. Learners study on-campus or through distance education. As with each of the selected courses, learners have access to an electronic Study Desk for interaction with academic staff and discussion about the course. Assessment for this course and the other courses selected for this research aims at constructive alignment (Biggs, 2001). Summative assessment is by two assignments and an examination.

The first assignment, worth 10% of course marks, is a mainly numerical assignment at the end of the first third of the course. It applies basic probability theory to cost risk management of two related project management activities. The second assignment, which is worth 50% of course marks, requires learners to develop a risk proposal for a company of their choice, outline a business case, and develop a risk management strategy for the company.

The examination, over two hours, worth 40% of marks, is designed to test learner knowledge of the whole course, and is conducted in a closed environment. It has a multiple choice component worth 10% of course marks, and a short answer/essay component worth 30% of course marks, which requires learners to answer three short answer questions.

Table 1 summarises the comparison of assessment in this course with authentic assessment. It indicates that while all forms of summative assessment in this course have strengths and weaknesses, the two assessment items worth 10% each (and in particular the multiple choice examination) had either “poor” or “acceptable” results only from the point of view of authentic assessment. This might be a result of their confined and specific tasks. The risk management proposal, which is strongly related to professional practice, rated well on all criteria. The examination, as expected, had a low rating on physical and social context, but apart from its multiple choice component had strength in the other criteria.

Of the 56 learners who studied this course in 2011 and 2012, 17 (30.4%) obtained Distinctions or High Distinctions and nine (16.1 %), all in 2011, failed outright. This percentage of failures in 2011 is expected to improve in the current year. While there is good use of reflective practice in the risk management proposal and the examination, this course has achieved a rating, for the weighted average score, of between “poor” and “acceptable” (2.5 to 3.3) with respect to authentic assessment, and therefore has considerable potential to be improved.

Table 1. Comparison of Existing Assessment of ENG8103 with Authentic Assessment

Authentic Assessment Element	Assignment 1 - 10% (Probability)	Assignment 2 – 50% (Risk Management Proposal)	Examination Part A – 10% (Multiple Choice)	Examination Part B - 30% (Short Answer)	Weighted Average Score
Task	3	4	2	3	3.0
Physical Context	3	4	2	2	2.8
Social Context	3	3	2	2	2.5
Result/form	3	4	2	3	2.5
Criteria	3	3	3	4	3.3
Professional	2	3	2	3	2.5

ENG8104 Asset Management in an Engineering Environment

ENG8104 Asset Management in an Engineering Environment primarily addresses strategic engineering asset management. Learner objectives may be summarised as understanding the role of engineering asset management; applying cost effective whole of life financial planning for engineering assets; evaluating and applying options for asset replacement, rehabilitation or upgrading; and evaluating and managing computer based asset management systems.

Teaching is divided into the two streams of asset management theory and applications of that theory. Learners in this course study either on-campus or through distance education. Assessment is by a mid-semester assignment and an examination, each worth 50% of course marks. The assignment covers material delivered in the first half of the semester, and is designed to learner knowledge and provide feedback. It has the following questions:

- An essay question, 3000 to 4000 words in length, worth 30% of course marks, which asks learners to develop an asset management strategy.
- A mathematical question, worth 20% of course marks, which requires the use of discounted cash flow principles for the comparison of two asset replacement options.

The examination, over two hours and worth 50% of course marks, aims to test learner knowledge of the whole course. It is conducted in a closed environment, and requires learners to answer four out of five questions.

Table 2 summarises the comparison of assessment in this course with their fit to the six authentic assessment elements. It indicates that all forms of summative assessment in this course have both strengths and weaknesses. While all assessment items were evaluated as good in criteria, and were acceptable or better in task, social context and form of assessment, the first question in the assignment was the only assessment item that was acceptable or higher in all criteria. The second question in the assignment was also acceptable or better with respect to authentic assessment criteria, but was weak in terms of professional issues. As expected, the examination had a poor fit in terms of physical context.

With respect to additional evaluation criteria, while there were positive learner comments about the industry relevance of this course, they tended to be about the course as a whole rather than its individual components. Of the 97 learners who studied this course in 2012 and 2013, 17 (17.5%) obtained Distinctions or High Distinctions and four (4.1 %) failed outright.

Table 2. Comparison of Existing Assessment of ENG8104 with Authentic Assessment

Authentic Assessment Element	Assignment Question 1 – 30% (Strategy)	Assignment Question 2 - 20% (Economics)	Examination (50%)	Weighted Average Score
Task	4	3	3	3.3
Physical Context	4	3	2	2.8
Social Context	3	3	3	3.0
Result/form	4	3	3	3.3
Criteria	4	4	4	4.0
Professional	3	2	3	2.8

As a result of a previous review of this course for authentic assessment (Thorpe, 2012), a question on depreciation, which had little professional relevance, was removed, and the relevance of all forms of assessment to professional practice was improved. Other innovations have included the increased use of reflective questions, and rubrics to improve marking consistency. Overall, the weighted average score of the fit of this course to authentic assessment is good with respect to criteria (score of 4.0), but still requires improvement in physical context and professional skills (scores of 2.8 in both). Course assessment is acceptable in the other elements.

Assessment of Future Specialist Technology

ENG8011 Assessment of Future Specialist Technology primarily addresses strategic engineering asset management. Learner objectives can be summarised as reviewing the evolution of selected present technologies; expressing an "informed guess" of future developments; incorporating predicted futures in development decisions; and weighing up the risk and reward of committing resources to innovation.

Teaching focuses on the practical development or reporting on an innovation selected by learners, who study the course through distance education. Assessment is by three assignments that progressively develop or report on the innovation. These assignments are:

- Assignment 1, a case study proposal of the learner's choice worth 20% of course marks. This assignment discusses a real company.
- Assignment 2, the first draft of the case study, is a due in mid semester and is worth 40%. It defines key issues and proposes innovative technological answers to issues.
- Assignment 3 is the final version of the case study. It is worth 40% of marks and is due at the end of the semester.

Table 3 summarises the comparison of assessment in this course with authentic assessment. It indicates that the fit of assessment in this course to the elements of authentic assessment is good with respect to all elements except social context, as learners tend to produce individual assessment, and in professional skills, where learners do not explicitly address sustainability and resilience. For both of these criteria, the fit for each of the individual items and the weighted average of all assessment items is acceptable.

This course is offered externally only and does not attract a large learner cohort. Its learners tend to be motivated to developing a good case study for an innovative proposal. This motivation is reflected to good grade achievement rates. Of the eight learners who studied this course in 2012 and 2013, four (50%) obtained Distinctions or High Distinctions and there were no failures. Learners are provided with marking criteria. A learner comment received on the most recent offer of this course was that course assignments were a logical progression to the final assignment. Overall, the course ranked highest with respect to its fit to authentic assessment.

Table 3. Comparison of Existing Assessment of ENG8011 with Authentic Assessment

Task	4	4	4	4.0
Physical Context	4	4	4	4.0
Social Context	3	3	3	3.0
Result/form	4	4	4	4.0
Criteria	4	4	4	4.0
Professional	3	3	3	3.0

Discussion and conclusion

The overall fit of *Assessment of Future Specialist Technology* to the authentic assessment principles used for the evaluation was of a quite good standard. The course performing poorest from this viewpoint was *Management of Technological Risk*. While assessment items that have a fairly wide scope and seek innovation from learners (such as the strategic asset management question in *Asset Management in an Engineering Environment*) tend to have an acceptable to good fit to the authentic assessment, very small items of assessment (worth about 10% of total assessment) tend not to have a good rating. The reason for this difference may be because such assessment items are not strongly related to workplace requirements and do not encourage innovation because they focus on particular answers. Examinations, possibly because of the restricted time for their completion and their conduct in an artificial environment, also did not rate highly against authentic assessment criteria. For example, in both components of the examination for *Management of Technological Risk*, only one element (criteria in the short answer component) was rated as “good” compared with the authentic assessment criteria. On the other hand, the assignment based assessment criteria for *Assessment of Future Specialist Technology* rated well against the criteria for authentic assessment, and drew positive learner feedback about the assessment process.

This research has demonstrated the advantages of authentic assessment processes, including the way in which they impact on results and learner perceptions. Because authentic assessment meets so many requirements of good assessment, the fit of an assessment item its criteria is an important element in assessment design for courses aimed at developing professional competencies. However, caution is required in considering whether to incorporate a particular assessment item in a postgraduate professional course because it is not rated highly against authentic assessment criteria. In making such decisions, the role of each assessment items in a course should be considered. Therefore, any changes to courses as a result of their evaluation against authentic assessment should be gradual. For example, after the previous review of *ENG8104 Asset Management in an Engineering Environment* for authentic assessment, a question on depreciation was dropped from the assignment because it added little value. The balance of the assignment was made clearer, and there is a closer industry link in the examination questions. Further improvements will be at a measured pace. Finally, the lessons learnt in this research will be applied at the outset to a course on advanced engineering project management that is currently under development. It is expected to have two industry and professionally relevant assignments, each building on the other, rather than an assignment and an examination.

In order to complete the evaluation of assessment in the selected courses against authentic assessment criteria, the findings of this research require verification through discussion with industry, professional and academic groups. Following this process, findings from the research as modified by this consultation process require dissemination to key stakeholders, with a view to piloting further course changes towards authentic assessment.

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