Confronting the Assessment Demon - Engineering Portfolio Assessment

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Abstract

It has always been challenging to develop appropriate and effective strategies for assessment of student learning. The move by professional bodies and universities to an outcomes focus has increased the challenge, and placed pressure on many traditional approaches to assessment. Portfolio assessment integrates with Project Based Learning (PBL) stratagems, and has improved student learning assessment in CQU engineering program PBL courses.

A course is defined by three key components, which are linked to each other inextricably. The overarching component is the learning outcomes, which the student must demonstrate to succeed in the course. Linked to this is the content, which provides a vehicle for students to achieve the learning outcomes. The final component, and equally important, is assessment, which is the means by which the student demonstrates achievement of the learning outcomes. The linkage of Learning Outcomes and Assessment through content is of paramount importance to the success of any course and ultimately the entire program.

The establishment of learning outcomes and the attendant content to enable their achievement is not difficult to achieve, however appropriate assessment is often very difficult to satisfactorily develop. Traditionally, formal examinations provided an assessment mechanism which yielded a quantifiable measure of the student's performance. Students desire to determine "what will be on the exam" often clouds the learning process, resulting in a superficial learning that is quickly forgotten after the exam is over.

Portfolio assessment thrusts the responsibility for the demonstration of the achievement onto students. Students are required to reflect on and ascertain what they need to demonstrate through the learning outcomes. Students are provided with a number of different opportunities for demonstrating the outcomes. These may include, amongst other things, formal skills audits (tests) which focus on specific core knowledge, but should include a need to delve significantly outside this to achieve higher grades. The challenging nature of the self discovery of knowledge and skills needed for that demonstration enhances the outcomes of the learning process for the student. Learning will tend to be broader, more integrated and more meaningful for the student.

Introduction

Central Queensland University has acknowledged the need for the design, development and delivery of innovative engineering programs, responsive to the practical needs of industry. A

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natural focus has been specifically the industries in the Central Queensland region of Australia. This focus has been explicitly acknowledged at CQU since the early 1990s.

By 1992, CQU's Bachelor of Engineering was established as a well regarded professional engineering program. CQU graduates readily found employment in the region's industries; primarily energy, transport and mining. Graduates of the program were recognised for their practical capability and appropriateness for professional engineering employment in (mostly) local and regional industry.

A faculty review of the Bachelor of Engineering program was conducted in 1992/3 in response to the changing professional requirements and needs of the industries. One prime consideration of the review was the broadening and deepening of the graduates' engineering practice knowledge and skills. The mechanism of achieving this was through greater exposure to, and experience in, engineering professional practice. The review included an extensive investigation nationally and internationally of engineering programs, focussing on co-operative education models. The outcome was the introduction of the Bachelor of Engineering (Co-operative Education) (BEng(Co-op)) program in 1994. The introduction of this program addressed the major issue of engineering practice exposure and experience, but maintained traditional delivery and assessment elements in the program without any curriculum or pedagogical changes.

A philosophical review of the BEng(Co-op) program was proposed and commenced in 1994, in parallel with the introduction of the Co-operative Education program. The aim of the review was to consider an alternative, improved learning paradigm that complemented co-operative education. A national study was co-incidentally being undertaken by the Institution of Engineers, Australia[1] which culminated in a 1996 report calling for significant change in how engineering programs in Australia were to prepare engineering students for their engineering careers.

In 1996 the Faculty completed the review and commenced planning for the redevelopment and restructuring of the professional engineering program[2]. As a result, the introduction in 1998 of the Project Based Learning (PBL) Bachelor of Engineering (Co-operative Education) introduced a new common first year and a significant reduction in the number of program courses. The program learning content refocussed in standardised 'size' courses with less class contact hours overall (down to 16 to 18 from up to 29 hours) and explicitly shifting part of the learning into student self-directed learning.

PBL was expected to prepare students to recognise and embrace the need to respond to significant social changes evident in the Australian engineering profession, especially in the context of sustainability, and that graduates needed to be aware of, and attuned to, their importance for their employment in their Co-operative Education work placement and on graduation.

Project Based Learning (PBL)

Project Based Learning specifically accounts for 50% of the learning for students in the CQU PBL Bachelor of Engineering (Co-op) program. In all terms of study, except when on Co-operative education placements, half of each term's student load is a single project based course.

The overall program curriculum is structured to allow the generic professional practice skills to be explicitly developed throughout the entire program. The first year of the PBL element of the program comprises two generic professional practice orientated courses. These two courses have minimal technical focus, but a specific emphasis on team working, communication, problem solving and 'professionalism' development. As students progress through the program, the technical elements are increasingly more substantial but there is still the requirement for the demonstration of higher level achievement of generic professional practice skills.

The initial operation of PBL resulted in many positive outcomes being identified. Evidence of more effective team and communication skills was apparent; students generally demonstrated more active and independent learning and an attitudinal change, and a thirst for more knowledge.[3] The experience of the offering also allowed areas for improvement to be identified[4], even within the first term of offering.

A major problem area identified by both the teaching team, and in a review report commissioned[5], was appropriate assessment. The key problem areas in assessment were the lack of individual assessment within the team, and the appropriate matching of assessment to the learning outcomes.

Students in Teams – 1998 Assessment

All project work in PBL courses is done by student teams. In 1998 each student's 'raw' grade was determined solely by their teams' project marks (simply collated), to which an individual 'moderation factor' was applied. The facilitator's assessment of the individual's participation together with a student's project team peers' assessment of an individual's participation constituted the moderation factor.

The 1998 project's, and hence students' assessments, were a traditional marking of a traditional, 'technical outcomes' focussed project report. The mark was dependent on the teams technical success (or otherwise) in the project, as opposed to assessing the individuals learning that occurred within the project. Student learning of the specific learning outcomes relating to the generic professional practice was not being considered. It became evident that the assessment was not addressing the demonstration of achievement of most of the learning outcomes.

Additionally, the moderation of team assessment into individual student grading through peer assessment and facilitator observation was considered potentially suspect, and would be difficult to justify if called to account.

The learning outcomes of the first year courses included predominantly generic professional practice knowledge and skills, with a low concentration of technical elements. The projects are used as a context for student learning, and consequently it is expected that learning occurs as part of the process of achieving the project goals. The faculty was confident, at the end of the first year of the program in 1998, that the learning outcomes (both technical and professional generic) had been met, but felt that the assessment did not actually assess the learning that had occurred. While the facilitation of learning had been transformed from a traditional style, the assessment items had remained traditional, in that they consisted of technical reports and oral presentations, and did not reflect the broader student learning.

An assessment method was required that would ensure that a high grade indicated high achievement in all the major learning outcomes, and that students could be failed for not achieving the major learning outcomes. This included the desire to stop students passing if they had had not developed and demonstrated acceptable standards in team work, communication, and even professional attitudes, even if they had achieved a suitable technical proficiency and problem solving.

Portfolios - a 1999 Assessment Paradigm Shift

In 1999, portfolio assessment was introduced into the common first year Project Based Learning courses of the Bachelor of Engineering program at CQU. This was done to address the perceived mismatch of the Learning Outcome and the assessment of those Learning Outcomes. These courses focussed predominantly on generic professional practice elements such as communication, teamwork, organisational skills and sustainability. Specific technical elements received minor coverage and often only implicitly.

In selecting portfolio assessment as the sole (i.e. 100%) assessment tool, a survey of methods[6] had provided some possibilities, together with information gleaned from a wide range of other sources. This decision was assisted by advice from colleagues from other faculties within the university and from outside the university who had previously used portfolio assessment.

The key features of portfolio assessment for project based learning generic professional skills courses that made it attractive were:

- decoupling of learning experiences from the assessment tool
- 100% individual student assessment
- assessing the learning
- allowing a diversified range of documented evidence to be presented
- encouraging innovative and creative thinking and solutions
- encouraging risk taking and inquiry in learning and determining solutions
- learning within projects, not specifically their outcomes assessed
- student responsibility to demonstrate learning against specific learning objectives and grade criteria
- students determining themselves areas in need of improvement
- supporting holistic learning and practice
- self and peer assessment could be incorporated
- processes of learning could be measured and documented over the term
- individualistic approaches encouraged in demonstration
- promotion of active learning through reflection
- difficulty in plagiarising
- allows assessment at the end of the term, which is what the grade is meant to indicate, rather than a summation of knowledge at various points in the term[7]

The successful introduction of portfolios into the first year of the program in 1999 was followed by the ad-hoc adoption of this assessment style in later years. This was as a result of staff who were exposed to this tool in first year in 1999, adopting it in their higher year level PBL technical courses in 2000.

As portfolios were promoted to other members of staff, some of them attempted to integrate this into their own courses, with varying interpretations and application, and degrees of success. This ad-hoc introduction continued with the third year of the program in 2001, with

some PBL courses portfolio assessed and some not. Of concern was the large variance in understanding and implementation of the concept, particularly in establishing student performance and grading.

There are issues that make grading of portfolios difficult. Some of those issues include[8]

- Portfolios with different pieces for assessment
- Lack of standardisation in portfolio components
- Amount of assistance students receive
- Portfolios constructed of 'best pieces' – which don't indicate sustained levels of performance

The ad-hoc introduction of portfolio assessment in later year PBL courses without oversight tended to exacerbate these problems. To overcome these issues, in 2002 the Faculty made the decision to adopt 100% portfolio assessment in all PBL courses. It was realised that such promulgation did not necessarily achieve uniformity in the interpretation and application of the philosophy. As such a series of staff forums and seminars were conducted to develop the necessary knowledge, skills and attitudes in staff to ensure a measure of conformity in the expected outcomes.

Development of Portfolio Assessment

Many of the identified issues were addressed in the further development of the portfolio assessment by the introduction of a number of work components to assist lecturers in identifying and utilising these as delivery and student self assessment of learning techniques. Students would then utilise and demonstrate how their learning from these activities contributed to their achievement of the course leaning outcomes. Examples of these are:

- Technical workbooks
- Design journals
- Project reports
- Audio Visual presentations
- Skills audit tests
- Reflective journals

These work components form a bank of potential components that individual course coordinators can choose from when structuring course delivery. The particular components chosen will depend in the type of course and the outcomes required. Some of these components are suggestions to students to help them to demonstrate their learning, while others may be compulsory items. The compulsory items may also be required to be assessed as satisfactory by lecturers. In particular, the different learning activities and their results or outcomes allow students to reflect on their learning and demonstrate the development of knowledge and skills over the term. It also provides for some standardisation of the portfolios. Compulsory inclusion of components such as design journals and technical workbooks ensures that the work presented is not just the 'best pieces', and show the development towards, for example, a project's outcome and the students attendant learning.

Portfolio Assessment of Technical PBL Courses

The delivery methods of the introductory PBL courses had undergone a significant paradigm shift. The assessment also required a significant paradigm shift. Extending portfolio assessment into technical based courses often yielded a hybrid amalgamation of new and

traditional philosophies together in the same course. One example is the course "Embedded Processor Systems", which is taught in the first term of second year of the electrical engineering plan. In 2001, the course profile stated:

"This course is delivered in the project-based learning mode. As such, assessment will be 100% by portfolio in which the workbook will form the dominant component. The breakdown of the total assessment into its various components is described in Part B."[9]

Part B then went on to give the assignment marking schemes and the following breakdown of assessment[9]:

Digital Electronics component

- *Projects x 3* — *30%*
- *Class tests x 3* — *30%*
- *Workbook* — *20%*

Microcontroller component

- *Programming Lab sessions* — *40%*
- *Workbook* — *10%*
- *Projects x 3* — *30%*

'Real world' System Design component

- *Term paper & presentation* — *20%*
- *Portfolio* — *20%*

This approach, not only conflicted with the statement on assessment, but also managed to de-integrate the course into three separate components with separate criteria and a summative assessment strategy. Clear parallels can be seen between the approach used in developing this assessment criteria and the experiences with the first year PBL courses in 1998. Once again, while the facilitation of learning had been transformed from a traditional style, the assessment items had not.

Additionally, the projects were delivered as a series of task-based activities, similar to the type of activities normally used in assignments in traditional courses. These activities do not achieve the intended goals of PBL, or allow appropriate assessment of the learning outcomes as discussed earlier in this paper and others[10]. It is clear from this mismatch that the assessment was based on a more traditional lecture-based teaching approach, whilst the delivery had been tweaked to align with the project-based philosophy. In this environment, students still achieve learning, but not as effectively as if the three course components are matched.

In 2002, the course coordinator of the Embedded Processor Systems Course was asked to teach in the well developed first year courses. In these courses, the PBL mode of delivery and portfolio based assessment were well matched and it was clear that the students achieved far better learning outcomes than in the second year courses. The experience enabled a significant shift in the understanding of portfolios to be achieved. This increased understanding was carried back to improve the learning outcomes in the second year courses.

Embedded Processor Systems Design underwent a significant redevelopment, which has been detailed in earlier papers[10]. The assessment has now moved to a genuine 100% portfolio base with the following description:

"Assessment will be 100% by a learning portfolio, in which students will reflect on what they have set out to learn, how they have approached their learning, what they have achieved, and what they would do differently in future to improve their learning effectiveness. This will occur at the end of the term. Students are also expected to nominate a grade that they should be awarded, in accordance with the published criteria as shown in Table 1. This clearly needs to be substantiated with evidence in support of such claims. The portfolio must contain the following compulsory pieces of assessment:

- *Reflective journal*
- *Reflective paper*
- *Workbook*
- *Self and peer assessment*

The assessment will be assisted by a final interview between each student and the teaching team. Students are expected to defend the grade that they nominate with evidence collated in their learning portfolio.

The overall grade, i.e., grades of High Distinction, Distinction, Credit, Pass, and Fail, will be awarded using criteria-based assessment process in accordance with the criteria schedule as per Table 1."[11]

The design projects were developed to be broad in their scope, so that different solutions are possible. In developing the project solutions, the students often make mistakes, which a more experienced practitioner would not make. These mistakes reinforce the learning of the students and allow them to develop a richer experiential framework of their own, rather than relying on the predetermined experiences delivered in a lecture based offering. The projects are supplemented by structured learning activities and delivered material, to allow students to more rapidly develop the specific base knowledge required to develop the project solutions. These activities also give students other avenues to develop evidence of their learning.

Regular meetings also form a significant part of the delivery of the course. Each team has a meeting time once per week, where issues can be identified, questions asked and advice and feedback given. This provides time for the lecturing staff to develop some closer knowledge of the individual students and the team dynamics, whilst ensuring the team is staying focussed and not drifting completely off-course.

Grades are not given for the individual projects, however verbal and written feedback is provided to students as formative assessment. This feedback typically identifies what was done well, and what could have been done to improve the project overall. This feedback, and the students reflection on it, also become part of the portfolio.

The final grading criteria applied are holistic and apply to the manner in which students have demonstrated their achievement of the learning outcomes in the portfolio. As stated previously, grading is not applied to each individual project or any individual activity of the students.

The criteria, an example of which is shown in Table 1., have no relationship to the success or failure of the design project outcomes. It is possible for the team to not achieve a successful result in one or both design projects, but for individuals within the team to achieve high grades due to their own demonstration of achievement of the learning outcomes. This is possible because the projects are not the only mechanism by which students develop evidence

of their learning. Therefore, other evidence can be presented to supplement the work done in the projects.

Grade	Criteria
Fail	Fundamental inability to demonstrate the acquisition of learned knowledge and skills, and/or an unprofessional attitude demonstrated by lack of involvement in the course and/or compulsory pieces of work are not included in the portfolio.
Pass	Individual student shows acceptable acquisition of learned knowledge and skills, and acceptable attitude and involvement in course. There is evidence of a reasonable effort towards the acquisition of knowledge and skills from the delivered content. This will be demonstrated by regurgitation of the delivered content.
Credit	Individual students understand the delivered content declaratively, in that they know about a reasonable amount of the delivered content, and demonstrate this by the ability to discuss delivered content meaningfully. In some instances they can apply learned knowledge and skills, but don't transfer it easily. Individuals recognise good and poor approaches to team, project and technical work - especially their own. Evidence of the development of a professional attitude and some technical awareness of the content is also a requirement for this grade.
Distinction	Individual student can consistently apply their learned knowledge and skills in a familiar context. They demonstrably use delivered content as a basis for team, project and technical work. Reflection and evaluation of their own work has demonstrated some improvement of decision making processes, but has also resulted in the development of a professional attitude and competent technical knowledge of this area.
High Distinction	Individual student is able to use their learned knowledge and skills in a different context to that in which it was delivered. This will necessitate demonstration of reflection on their own work as well as the team's work, evaluation of the decisions made within the projects in terms of what they have learned, and thereby improvement of their decision making and team skills.

Table 1 Typical PBL Course Grading Criteria

The Assessment Process

The individual folios have some variation due to the students developing their own personal style of presentation; however they tend to follow a generic format. The portfolio should begin with a summary identifying the grade the student believes they have achieved against the criteria in Table 1. The nomination of grade plays a part in the assessment process. This is the first impression for the assessor, who also has knowledge of the student from workshop interaction and observation. If the student has clearly over or under assessed themselves, then an immediate conclusion can be drawn about their level of professional understanding of themselves and the course content.

Following the students nomination of grade in their portfolio, they typically address the learning outcomes. Although the format can vary, the most common approach is to address each learning outcome individually. Their claims must be demonstrated through reference to evidence included in the folio as appendices. This provides a "roadmap" for the assessor to navigate through the volume of the students work. This should identify the evidence that is relevant to each particular learning outcome and some explanation. Generally, each learning outcome would not require more than a typed A4 page; however the actual size varies according to the individual student's capacity to address that learning outcome.

Following the addressing of the learning outcomes, students would normally include self and peer assessment. The self assessment is a more detailed version of the nomination of grade summary. The student should justify their choice of grade against the criteria presented in Table 1 and using the evidence in the rest of their portfolio. The peer assessment should assess their team members against the same criteria, but with less depth, as they only have observational evidence of the performance of their peers.

The remainder of the folio is then the evidence collected by the student throughout the term. The process of assessment is then one of progressively verifying the student claims against the evidence presented, the experience of the facilitator and the peer assessments of that student. The assessor either supports the nomination of grade by the student, or indicates why an alternate grade is appropriate against the criteria in Table 1. It has been the experience of the facilitators that the students who have developed more professionally and technically are able to provide a clear "roadmap" and are far easier to assess because the evidence is obvious.

Conclusion

Portfolio assessment is a mechanism of assessing student learning in PBL courses. The responsibility for the demonstration of the achievement of the courses' learning outcomes is specifically the student's. Reflection on, and determination of, what they need to demonstrate against the learning outcomes is a key element. The challenging nature of the self discovery of knowledge and skills needed for that demonstration enhances the outcomes of the learning process for the student. Learning will tend to be broader, more integrated and more meaningful for the student.

An issue in the PBL courses was an inconsistency in the portfolio development required of the students and its assessment. Without guidelines, staff had considerable variations in their perceptions of what was to be included. Consistency was achieved through the adoption of a standardised set of elements, and their treatment, that could provide formative assessment of students and be tailored to a range of different courses. Portfolio assessment is now the designated assessment strategy for all PBL elements of the Bachelor of Engineering Programs at CQU.

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