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**AN ONLINE STUDENT PORTFOLIO
FOR THE DEVELOPMENT AND
ASSESSMENT OF ENGINEERING
GRADUATE ATTRIBUTES**

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An Online Student Portfolio for the Development and Assessment of Engineering Graduate Attributes

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Abstract

An online student portfolio was evaluated as a means for engaging students with the concept of graduate attributes, and for documenting student attainment of graduate attributes. Students rated the portfolio system as easy to use, and indicated that it helped them to appreciate the skills and knowledge they had developed.

Introduction

Internationally, engineering education accrediting bodies (amongst other disciplines) have moved toward outcomes-based assessment of graduate competency. This is typically realised in the form of a list of graduate attributes that students should exhibit by the completion of their undergraduate studies. Such an approach requires both student engagement with the concept of graduate attributes, and the means to document individual student attainment of the necessary graduate attributes. The literature suggests that online student portfolios are a means for achieving both of these requirements. This paper presents the development and evaluation of an online student portfolio as a means of engaging undergraduate engineering students with the concept of graduate attributes.

Graduate attributes

Arising from the push in higher education for quality assurance, accountability for outcomes and capability of graduates (Leathwood & Phillips, 2000), specifying a list of qualities or capabilities that graduates will attain provides a benchmark against which the performance of a higher education institution can be measured. In engineering education, the idea of specifying required student outcomes in terms of graduate attributes has been embraced internationally for some years (Jolly, 2001; Lister & Nouwens, 2004), and this remains the case in Australia (Engineers Australia, 2005a), the USA (Engineering Accreditation Commission, 2007), and the UK (Engineering Council UK, 2004).

In the literature related to graduate attributes, there can be observed varying levels of sophistication in approach. The range includes:

- identifying and prioritising desirable graduate attributes (Scott & Yates, 2002);
- identifying where and at what level in the curriculum attributes should be covered (Atrens, Truss, Dahl, Schaffer, & St John, 2004; Chapman, 2004);
- designing assessment to explicitly measure graduate attributes (Yeo, 2004);
- evaluation of the effectiveness of delivery of graduate attributes (Bullen, Waters, Bullen, & de la Barra, 2004); and
- evidence-based certification of attainment of graduate attributes (Williams & Sher, 2004).

Designing a program curriculum to expose students to a range of graduate attributes is a necessary step, but, in itself, it does not ensure that students have developed the desired attributes. One element of such an assurance is including assessment tasks that seek to measure the student's attainment of the desired attribute(s). A 'pass student' may progress through their entire program and successfully complete their studies having avoided a range of graduate attributes that were designed into the curriculum and dutifully assessed (C. Ferguson, 2001). It is important to make the distinction between processes which ensure that a program will contain opportunities for the student to be exposed to, and to practice desired attributes, and, processes which seek to certify actual student attainment of graduate attributes. Student portfolios are one means by which individual attainment of graduate attributes can be assessed.

Student portfolios

All three of the undergraduate engineering accrediting bodies in Australia (Engineers Australia, 2005a), the USA (Christy & Lima, 1998) and the UK (EPC Assessment Working Group, 2002) identify student portfolios as one possible strategy for demonstrating program outcomes and student

attainment of graduate attributes. Love & Trudi (2004) summarise the benefits of portfolios as:

- they can contain many different types of evidence;
- they resolve many types of assessment problems in equity and moderation;
- they provide a richer picture of students' learning and competency;
- students are actively involved in the building of the portfolio;
- they are well suited to authentic learning environments;
- they can be used in a wide range of contexts; and
- they provide a means for students to manage their own professional development.

Importantly, for the task of assessing outcomes of an entire program of study, a portfolio can act as an integrator, bringing together and assessing the whole program (Manson, Pegler, & Weller, 2004), including allowing students to demonstrate attainment of particular attributes that may not have been explicitly summatively assessed at any point during their studies (EPC Assessment Working Group, 2002).

It has been found that the portfolio requirements and the structure/format in which portfolio items must be submitted need to be designed around the intended use of the portfolio, and made clear to students who will be using the portfolio (Allan, Zylinski, Temple, Hislop, & Gray, 2003; Heinricher et al., 2002). Additional effort in compiling the portfolio can be minimised by basing it around assessment items/artefacts already currently produced by students (Falk et al., 2002; Heinricher et al., 2002; Lohmann, 1999). It is well known that students take a strategic approach to study, and the learning activities they engage most fully with are those most clearly associated with what will be assessed (James, McInnis, & Devlin, 2002). Not surprisingly, it has been observed that attaching assessment credit (marks) to the completion of portfolio tasks is an effective motivator for student engagement (Christy & Lima, 1998; Heinricher et al., 2002; Toohey, 2002). While it is possible to employ a paper- or hardcopy-based student portfolio, the increasing use of online technology by students and educators alike, including in assessment, means that many of the reported applications of student portfolios are online portfolios (or, e-portfolios) (Dixon, Dixon, & Pelliccione, 2005; Love & Trudi, 2004; University of Sydney Faculty of Science, 2004; Williams & Sher, 2004).

While student portfolios are often presented as the panacea for a multitude of educational ills, a range of authors have noted possible issues with the use of portfolios. The term 'portfolio' has a multitude of meanings; portfolios are used for many purposes; and the understanding of, and approach to, assessment employed by the assessor(s) are likely to influence student learning as much as any particular assessment vehicle (Godinho & Wilson, 2005). Portfolios provide 'discernible traces of performance', as distinct from the actual performance of a skill or the application of specific knowledge, hence, their contents are open to interpretation by assessors (Hay & Moss, 2005). In the context of the assessment of professional standards and professional

accreditation of teachers (a scenario not dissimilar to the assessment of student attainment of attributes required for graduate membership of the engineering profession), it has been noted that portfolios structured around tightly specified professional criteria may lead to a conformity of outcomes that is not in the best interests of students or the profession (P. Ferguson, 2005). We need to be aware that simply changing the assessment format does not absolve us of the need to critically consider the purposes of assessment, what will be assessed, who will perform the assessment, and the criteria that will be employed in assessment.

Online student portfolio trial at Deakin University

The School of Engineering and Information Technology at Deakin University in Australia offers a four year Bachelor of Engineering (BE) at undergraduate level. The program is delivered in both on-campus and off-campus modes. The first author had academic responsibility for the fourth-year, final-semester engineering management / professional practice study unit SEB421 Strategic Issues in Engineering. Because of the existing diversity of assessment tasks in the unit, the location of the unit as a 'capstone' in most students' studies and the existing use of online submission for student work, SEB421 was chosen as a context to evaluate the use of an online portfolio as a tool for documenting individual student attainment of graduate attributes. The strategy of initially positioning online student portfolios within the context of a final-year professional skills units is noted elsewhere in the literature (Lane, 2007).

An initial task in this project was the development of a set of applicable graduate attributes for the students enrolled in Deakin University's engineering programs. For undergraduate engineering education at Deakin, there are three principal references for required graduate attributes. They are: i) the Attributes of a Deakin Graduate Procedure (Deakin University, 2005); ii) the Engineers Australia Policy on Accreditation of Professional Engineering Programs (Engineers Australia, 2005b); and iii) the Engineers Australia Australian Engineering Competency Standards – Stage 1 Competency Standards for Professional Engineers (Engineers Australia, 2004). Based on these reference documents, a list of 32 graduate attributes was synthesised, under 12 broad categories. Based on these identified engineering-specific graduate attributes, a subset of attributes was selected that were appropriate to the context (both content and assessment tasks) of the unit SEB421, those attributes were:

1. Proficiency in engineering design;
2. Ability to communicate effectively, with the engineering team and with the community at large;
3. Manage own time and processes effectively, prioritizing competing demands to achieve personal and team goals and objectives;
4. Fluency in current computer-based word-processing and graphics packages; and
5. Capacity for creativity and innovation.

Previously, SEB421 included an assignment task, worth 10 percent of the unit marks, based on students compiling an online reflective journal relating to their unit studies across the semester. This was replaced by the online portfolio task described below. Note that 'DSO' refers to Deakin Studies Online – the online course management system used by Deakin University.

This assignment seeks to identify a specific subset of the graduate attributes that apply to your engineering studies, and to get you to personally reflect on how you have developed and demonstrated these knowledge, skills and attitudes. To demonstrate your individual attainment of these graduate attributes, you need to submit two items for each of the five attributes:

1. **Evidence** – Tangible evidence, in an electronic form that you can upload into DSO, that demonstrates your attainment of the specified graduate attribute. Possible evidence formats include written work (Word files), presentations/visual aids (PowerPoint files), computer programs (code source files), audio recordings (sound files), short videos (video files), photographs, etc. You can be creative here, but, please keep in mind that uploading large files into DSO may cause problems, and, the file formats you choose should not require any special software for opening/viewing.

2. **Reflection** – Reflection on one's experiences is recognized as one of the most important means by which practicing professionals (such as engineers) continuously build their knowledge from their experiences. Please write at least 200 words of personal reflection on your attribute evidence that demonstrates that you understand the importance and relevance of the attribute to your development as a technology professional.

The literature on student portfolios identifies that student reflection is an important part of extracting learning value from a portfolio, and the reflective journal had been an intentional and overt component of SEB421 in the past. For this reason, student reflection on portfolio entries was included/retained in the new assignment task, and both the submitted 'evidence' and student reflection elements were assigned marks. While primarily structured around graduate attributes, the portfolio did invite students to engage with modern forms of assessment evidence (Elliot, 2007) that was:

- naturally occurring – students were encouraged to 'mine' their own archive of assessment artefacts created during their prior studies;
- digital – evidence had to be digitally 'uploadable';
- multimedia – any reasonable media was acceptable; and
- distributed – where appropriate, links to existing online material were used as evidence, rather than the re-submitting the items themselves, i.e., a URL link to a YouTube video clip.

As this was a trial, it was decided to conduct a formal evaluation to establish students' prior knowledge of graduate attributes and use of portfolios, to determine how their knowledge of graduate attributes developed through using the portfolio and to determine attitude to usage of the portfolio system. The evaluation included pre-semester and post-semester surveys of students,

and as required by the Deakin University Human Research Ethics Committee, these surveys were anonymous and voluntary.

Evaluation

During week 1 of the academic semester, the initial questionnaire was posted to all off-campus enrolled students, and on-campus students were invited in the first class to complete the questionnaire. During weeks 12 and 13 (the final two weeks) of the semester, on-campus students participated in assignment presentations, ensuring a good attendance. As students completed their presentation, they were invited to complete the follow-up questionnaire. The questionnaire was posted to all off-campus students in week 12 of the semester. In-class and postal questionnaire returns were collected and the data keyed. 48 valid responses were received from a commencing class enrolment of 79 students (response rate = 60.8 percent). 50 valid responses were received from a completing class enrolment of 70 students (response rate = 71.4 percent). The gender and mode of study characteristics of the entire class group were known, permitting a comparison of the population and respondent groups. There was no significant difference between the respondent and population groups (commencing and completing) with regard to gender (small-sample test of proportions based on the Binomial distribution) and mode of study (chi-square goodness-of-fit test). The comparatively high response rate and good match between the demographic characteristics of the sample and population groups suggests that valid conclusions about the population group can be inferred from the respondent group.

Respondents were asked to indicate their agreement (or not) with a series of questions. The questions, the levels of agreement pre-test (start of semester) and post-test (end of semester), and, the statistical significance of the difference is summarised in Table 1. While more than half of respondents were initially aware that Engineers Australia specifies required graduate attributes, only one third were aware that Deakin University does the same. One third of students did not appreciate the link between study and assessment, and the development of graduate attributes. Initial exposure to student portfolios was low; less than half of respondents understood the purpose of a student portfolio, and prior use of student portfolios was reported by less than one in six respondents. Many students encountering a student portfolio for the first time will require proper orientation to understand the purpose and operation of any portfolio system. The higher end of semester levels of agreement were all significantly different.

Question	Pre-test	Post-test	Significance
Aware of the concept of graduate attributes?	45.8 %	100 %	$\chi^2_1 = 36.86$ $p < 2 \times 10^{-9}$
Aware that Engineers Australia has a list of graduate attributes?	52.1 %	96.0 %	$\chi^2_1 = 24.86$ $p < 7 \times 10^{-6}$

Aware that Deakin University has a list of graduate attributes?	33.3 %	94.0 %	$\chi^2_1 = 39.26$ $p < 4 \times 10^{-10}$
Link between study & assessment, and development of GAs?	66.7 %	94.0 %	$\chi^2_1 = 11.71$ $p < 7 \times 10^{-4}$
Understand the purpose of a student professional portfolio?	43.8 %	96.0 %	$\chi^2_1 = 32.09$ $p < 2 \times 10^{-8}$
Previously used hardcopy portfolio?	14.6 %	-	-
Previously used electronic portfolio?	14.6 %	-	-

Table 1 – Agreement with evaluation questions pre-test and post-test

Respondents were asked to report the frequency of their usage of the online portfolio system based on a scale of daily, weekly, monthly and other. The responses were: daily – 8.0 percent; weekly – 46.0 percent; monthly 36.0 percent; and ‘other’ – 10.0 percent. Of the five ‘other’ responses, two were given as ‘fortnightly’, two were given as ‘once only’ and one was given as ‘three times’. While student were only required to submit five portfolio entries (which potentially could have been made all at the same time), and the minimum required frequency of access could have been low, more than 50 percent of respondents reported accessing the system weekly or more frequently. Students who had made their portfolio submissions were encouraged to ‘publish’ their submissions and make them publicly available for other students to view; 35 portfolio items were published by students in the class. The availability of these published submissions may have be a factor that encouraged students to access the portfolio system frequently, to view the example submissions from their peers.

Respondents were asked to rate the ease of use of the online portfolio system based on a scale of 1 = very difficult to 5 = extremely easy. The mean response was 3.98, with a standard deviation of 0.74. The median response was 4. The range of responses was 2 to 5. 96.0 percent of respondents reported that they clearly understood the purpose(s) of the online student portfolio. While the implementation of the online portfolio system using the standard features of DSO was not particularly straightforward or user-friendly, these results indicate that students did not find the system particularly difficulty to use. Respondents were asked to indicate what aspects of the online portfolio system that they found most useful. The responses were grouped into categories, and Table 2 presents the categories and ranked frequency of occurrence.

Reported <u>most</u> useful aspect	Frequency of reporting
Helped to develop an understanding of skills gained	15
Assess / appreciate the skills of other students	4
Recognize what students lack compared to professionals	4

System was simple / convenient	4
Ability to gradually build a portfolio	3
Access to information	1
Unsure	1

Table 2 Reported most useful aspects of the online portfolio system

The most frequent responses relate to students developing an understanding of the skills that they and/or their peers have developed during their studies, as well as being able to appreciate perceived gaps in their skills compared to practicing professional engineers. A number of respondents indicated that the system was easy to use. Respondents were asked to indicate what aspects of the online portfolio system that they found least useful. The only response received with a frequency greater than one was that there were no 'least useful' aspects. A small number of the negative comments relate to operational aspects that arose in this initial trial, and have already been noted for future adjustments to portfolio requirements and processes.

A range of student demographic and portfolio usage information was available, including:

- gender;
- age;
- mode of study (on- or off-campus);
- weighted average mark (WAM – a proxy for general prior academic ability);
- number of portfolio entries (a proxy for 'quantity' of engagement);
- average mark per portfolio entry (a proxy for 'quality' of engagement);
- number of portfolio entries read; and
- final unit mark (out of 100 – a proxy for unit learning outcome).

Multivariate linear regression analysis was conducted with 'final unit mark' as the dependent variable. All other known variables were initially introduced as independent variables, and step-wise regression was performed until all remaining variables were significant. Two variables were found to be significantly related to final unit mark; WAM and number of portfolio entries. An analysis of variance test suggested that the regression model was significant ($p < 7 \times 10^{-17}$) and the regression residuals were approximately normally distributed, although, the model predicts only 55.7% of the variation in the final unit mark. While the regression model should not be interpreted literally as the 'formula' that determines a student's final unit mark, it suggests that:

- by the (nominally) final semester (out of eight), a student's WAM (based on the average result for 28 out of 32 units) is a strong predictor of final unit mark; and

- based on a regression coefficient of 1.80, each portfolio entry contributed about the mean mark (1.86 out of a possible 2.0) per portfolio entry observed across the entire class.

Although students reported being able to 'assess / appreciate the skills of other students' as a useful feature of the portfolio system, the number of portfolio entries read was not found to be significantly correlated to final unit mark, suggesting that the value of this 'feature' may have been more perceived than real. None of the known demographic variables (gender, age and mode of study) were found to be correlated with number of portfolio entries made, suggesting that the online portfolio task was an assessment activity that all groups of students could participate in on an even and fair basis. While the focus of this exercise was primarily as a context in which to engage students with the concept of graduate attributes, the assessment of portfolio entries was used as an opportunity to provide formative feedback to students (Boyle, 2007).

Conclusion

There is little doubt that graduate attributes will continue to be a focus in higher education generally, and certainly in engineering education. There will almost certainly be a move toward certification of individual student attainment of graduate attributes, rather than simply certifying that programs of study provide opportunities for students to participate in activities designed to develop particular graduate attributes. Student portfolios are one means for collecting artefacts, performances, reflections and other evidence to document student attainment of graduate attributes. Given the growing influence of online learning environments, coupled with the fact that much student work is now electronically generated, it is likely that online portfolios (e-portfolios) will play an increasing role in the graduate attributes arena.

A trial of an online student portfolio as a means of engaging undergraduate engineering students with the concept of graduate attributes was undertaken. The awareness of issues relating to graduate attributes (particularly awareness that Deakin University specified a list of graduate attributes) rose dramatically from the beginning of the semester. Participation in an assessable activity (the online portfolio) structured around an identified subset of engineering graduate attributes, and the provision of background information about graduate attributes as part of the assignment requirements appears to have developed this increased awareness. Students generally rated the online portfolio system as easy to use, and indicated that it had helped them to appreciate the skills and knowledge they had developed in their undergraduate studies. The literature suggests that portfolios are one means for meaningfully engaging students with graduate attributes, and, the results obtained in the trial reported here lend support to that proposition.

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