

# Capstone Portfolios for Learning and Evaluation

**Aaron S. Blicblau**

Swinburne University of Technology, Melbourne, Australia  
ablicblau@swin.edu.au

**Abstract:** Portfolios are a collection of student work over a period of time. Capstone project portfolios incorporate many forms of written artefacts, e-pages, electronic samples as well as audio-visual material. The development of writing skills from minor project proposals to major reports or dissertations is an ongoing learning exercise for the student. For the educator, portfolio development is a method of continuously evaluating and commenting on a student's work, culminating in a final major report. This portfolio report may be in traditional format, or may take the form of several artefacts, viz. electronic portfolios, written report, computer program 3D model, paper poster, (WWW) web page and electronic posters. As well as the incorporation of oral presentations which develop communication skills for working within an industrial environment. However, for academic purposes stratification of assessment grades is required, by both peer group assessment and independent academic assessment. Examples of capstone portfolio content will be given showing that which is submitted formally, and that which remains for the students' learning.

**Keywords:** Portfolio, capstone, projects

## Introduction

The work outlined in this paper provides details of the design and development of a *portfolio* approach to the implementation of a "capstone" or final year project undertaken by mechanical, and robotics and mechatronics (R&M) engineering students at Swinburne University of Technology. New methods of communications and dissemination of information have necessitated new approaches to the outcomes of capstone projects. In addition, graduates are now required to be both engineers and communicators. Whereas, traditionally a written thesis was the only major outcome of honours or capstone projects, industry now expects graduates with skills(outcomes) not only in their areas of training, but also be adept with electronic, "e", forms of communication. Electronic portfolios, commonly regarded as "e-portfolios" where all student work and assessable material is uploaded onto a computer website or learning management site (e.g., WebCT or BLACKBOARD); have altered the form of the outcome learning by students. They transmit their data electronically, are assessed electronically and complete their studies electronically. However, within most industries and organisations, electronic (computer) tools are only used as an aid in communication; usually in the form of audio/visual presentations, and written reports are still the key form of important communication.

Details are given of an electronic portfolio, "e-portfolio", which was developed for use by final year engineering students. The portfolio encompassed digital, electronic, audio/visual,

oral and paper based content. Utilising a variety of portfolio content (e.g., Brodeur, 2002) would enable the student to both learn how to communicate in different media as well as self assess their work in different contexts.

### **What is a Portfolio?**

...*portfolio*...Italian portafoglio : porta-, from *portare*, to carry, from Latin portāre + foglio, sheet (from Latin folium, leaf)...a portable case for holding material, such as loose papers, photographs, or drawings. The materials collected in such a case, especially when representative of a person's work: a photographer's portfolio; an artist's portfolio of drawings: *an engineer's collection of designs, calculations, digital media* (e.g., *Answers*, 2006, *Wordsmyth*, 2006).

A student portfolio has been recently defined by Paulson et al (1991) as "a purposeful collection of student work that exhibits the student's efforts, progress and achievements in one or more areas. The collection must include student participation in selecting contents, the criteria for selection, the criteria for judging merit and evidence of student self-reflection." However, not all portfolios are the same. Especially in the engineering field, portfolios are produced for a variety of personnel and purposes. A well designed portfolio serves two main purposes: it allows academic staff to employ it as a tool for assessment and feedback, and for prospective employers to evaluate the quality of their new employees.

Recent work done by Columba & Dolgos (1995) in developing portfolio concepts for mathematics education, defined basically three types of portfolios: *showcase* (which focused on the student's best and most representative work.), *teacher-student* (the "working portfolio") and *teacher alternative assessment* (specific portfolio items are selected for assessment). Each served a different purpose. Selections from each portfolio concept can further be incorporated to design a "holistic" portfolio for engineering applications. Portfolio assessment can help students understand their strengths and weaknesses. Furthermore, Gilman et al (1995) maintain that portfolios provide information about student progress and encourage students to be responsible for their own learning. In this way they feel as though they take more responsibility in their learning and assessment processes. Portfolios are seen to assist students in developing skills necessary for life-long learning; and enable thinking skills with multidimensional forms of evaluation.

### **What do we want students to know from capstone project work?**

The Institution of Engineers Australia (Engineers Australia, 2005) has developed generic criteria which all students need to attain by the time they graduate. In particular, these are specific to project work, and for students, capstone project work. A selection of these of these attributes is given in table 1. Students entering the workplace are expected to demonstrate mastery of a number of skills as identified by Axley (1990) and emphasised by editors of the Fortune 500 companies (e.g., Fortune 500, 1990), as listed in table 1. A comparison of the attributes and skills indicates that the generic engineering skills components completely encapsulate those seen as necessary for a large organization.

All components of the generic attributes criteria may be included in a capstone project, and assembled in a portfolio. Each attribute may be highlighted in electronic, paper, audio-visual or digital format. These in turn contribute to the requirements students need to master to be able to succeed in the outside world working in industry or business. Examples of this approach have been developed by Wellington et al (2002) for capstone projects which integrated both engineering and business students.

<p>(Engineers Australia) GENERIC ATTRIBUTES Graduates are expected to be able to</p> <p>apply knowledge of basic science and engineering fundamentals;</p> <p>communicate effectively, not only with engineers but also with the community at large;</p> <p>in-depth technical competence in at least one engineering discipline;</p> <p>understand problem identification, formulation and solution; function effectively as an individual and in multi-disciplinary and multicultural teams, with the capacity to be a leader or manager as well as an effective team member;</p> <ul style="list-style-type: none"> <li>• Understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development.</li> <li>• Understanding of the principles of sustainable design and development;</li> <li>• Understanding of professional and ethical responsibilities and commitment to them;</li> <li>• Expectation of the need to undertake lifelong learning, and capacity to do so.</li> </ul>	<p>FORTUNE 500 GENERAL SKILL MASTERY Graduates are expected to be able to utilise</p> <p>Teamwork</p> <p>Problem-solving</p> <p>Interpersonal Skills</p> <p>Oral Communication</p> <p>Listening</p> <p>Personal/Career Development</p> <p>Creative Thinking</p> <p>Leadership</p> <p>Goal Setting/Motivation</p> <p>Writing</p> <p>Organizational Development</p> <p>Computation</p> <p>Reading</p>
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**Table 1. Comparison of attributes required by graduates and “big business” (Engineers Australia, 2005; Axley, 1990; and Fortune 500, 1990).**

## The Engineering Capstone Project

Traditionally final year mechanical engineering projects at Swinburne University are conducted over the last two semesters of the final year of a four year engineering degree. The project value is 25% of the total units studied by students for that year. The makeup of the project comprises a number of components some of which can be transmitted in “e”, electronic format but are often viewed and presented in both orally and in “hard” or paper format.

A conventional capstone project would require the students to spend most of their time undertaking a specified form of research or design approach over two semesters, culminating in a minor thesis and often an oral presentation. The project often required significant commitment and resources by the university or the sponsoring industrial organisation. This approach was based on the “honours theses” approach common in the fourth year of science and humanities degrees. The only outcome was 50-100 page report, often in a manila folder or sometimes hard bound. According to Webster et al (2000) the report gave little indication of the student’s overall abilities in a variety of areas and skills. Other forms of representations were necessary for student assessment.

## Capstone Portfolio Project Structure

According to criteria established and codified by the Prince George County College System (2006) and based upon the ideas developed by Paulson et al (1991), the portfolio structure undergoes a number of phases of development.

**Phase one: organization and planning**

This initial phase of portfolio development requires decision-making on the part of students and project proposers/supervisors. By exploring essential questions at the beginning of the process, students can fully understand the purpose of the portfolio and its status as a means of monitoring and evaluating their own progress.

The development of the portfolio project commences with the first time the students meet their project proposers. At the commencement of the first week of the first semester, all students assemble to hear their project sponsors “spruik” the benefits of their project. Important questions which the student needs to consider and so learn about project proposals and tendering, include the following. How do I select the project? How do I design/analyse/organize and present the information, data, items, materials, etc? Concomitant with these decisions is the requirement of portfolio content; how will portfolios be maintained and stored? Will it contain various forms of artefacts in a number of physical and multimedia formats? For example, written, oral, electronic, web based learning management systems, poster and audio displays and the traditional bound notebook.

The compilation of the portfolio is spread over two semesters with specific requirements for submission of different artefact over a variety of dates. Shown in Table 2 is a typical portfolio content with submission and assessment requirements.

<b>Portfolio Content</b>	<b>Format</b>	<b>Assessment Form</b>	<b>Submission</b>
Summary of available projects	Paper, electronic, audio-visual	Students “assess” project and select supervisor	A contract is submitted by both student and supervisor
Project proposal	Audi-visual, web based, written	Peer group, independent assessors	At end of specified time span i.e. 10 weeks from project selection.
Written report Journal or conference paper e-poster - web page Electronic A/V presentation A1 size professional poster Computer programs, models, designs, CAD, FEA and 3D physical structures	Paper Electronic-digital Visual Physical model Computer model Oral presentation	Peer group  Independent assessors  Ranking  Numerical	Subject to specific time constraints: All items submitted at the end of semester two but before the commencement of the exam period.

**Table 2. Content and details of the capstone portfolio**

The portfolio submission requirements are allied to that of a *tender* process which comprises many stages (e.g., Tender Consulting, 2006). The students begin their portfolio collection on the very first day – with the oral presentations and associated written material describing the various projects. This concept of a portfolio is at first foreign to the students. They are used to submitting final pieces of work for assessment. Student need to evaluate comprehensive technical literature (e.g., Krishnan and Kathpalia, 2002) often in the form of complex

documents and produce a persuasive and effective tender/project proposal. This is the first important stage in the portfolio comprising the capstone project.

Portfolio capstone assessment can take many forms and is often dependent on the contents and outcomes of the project (e.g., Panitz, 1996 and Paretti, 2005). The breakdown of marks for the various parts of the Stage One portfolio is distributed as follows: for the electronic audio-visual presentation-(20%), the “e-poster”-(20%) and the supplementary written report (60%).

All proposals are required to be submitted in electronic-digital format, with supporting written material by a specified *closing* date. The assessable items comprise an audio-visual presentation, an e-poster ( a poster for display on the WWW and a written proposal). This is the first stage of the bid in the form of a preliminary tender submission. To enable students to take ownership of their assessment, they are peer assessed. At the end of 10 weeks a colloquium is presented by all students in the form of a five minute “project blitz” to all their colleagues and academic staff members, delivered under tight time constraints and on top of other student work.

The assessment technique for all three items is varied. Students “vote” on each others’ work (e.g., Miller, 2004). For example oral presentations and e-posters. These e-posters are ranked from outstanding, very good, acceptable and not acceptable. The associated numerical marks (as required by the tertiary institution) start from ten, then eight and six to finally four, respectively. The best poster gets the best marks whilst the worst poster gets the worst mark. The students view all the posters electronically, know the assessment, and so learn from each others’ work.

Similarly, students vote on the “project blitz” presentations. Over the past few years, there have been over 60 assessments for each student, so that a normalised set of data are obtained with a minimisation of any bias. A binary form of grading is all that is required; is the project proposal acceptable to proceed to the next stage? There is no numerical grade attached to this form of assessment.

However, for the written supplementary report, a more comprehensive system is utilised (e.g., Olds, 1997 and Ostheimer and White, 2005). Two independent academic staff assess the reports based on specific criteria. Each component of the report is examined and a final numerical grade is attached to written component. Further, the bulk of the portfolio content is yet to be developed and assembled for the final work. This involves a substantial amount of experimental/design/simulation items with associated artefacts for collation in the portfolio.

### ***Phase Two: investigation and compilation***

With the feedback from assessment of stage one portfolio, the students are able to reflect on the benefits and shortcomings of their initial submission. Phase two of the portfolio compilation now commences.

Investigation and Compilation - This process involves investigations and collection of meaningful designs, analyses, physical artefacts and products reflecting the students' engineering experiences and associated outcomes. From all the information obtained, decisions must be made at this phase about the context and contents of the portfolio based upon the intent and purposes of the project. At this stage the direction and specific targeting for project outcomes is assessed in light of the original proposal.

For the student this is a time for reflection and monitoring of their evolving comprehension of key engineering knowledge and skills. Because of capstone portfolio time and written submission constraints, these reflections often take the form of intensive oral debates with peers and supervisors; and submission of preliminary extensive written and digital documentation for 'comment' (e.g., Sharp, 1997 and Snaveley and Wright, 2003). For the student the results from these reflections are learning and educative process, incorporating their own and colleagues' experiences, the thinking processes that they have used, and the different approaches to solve the problems that they employed at given points in time during the management of the project across time periods.

For assessment all components selections included in the portfolio collection clearly reflects the criteria and standards identified for evaluation. The assessment technique for the second phase of the capstone project is similar to the first stage with the incorporation of independent assessors for all facets of the portfolio submission. The assessable content are; oral presentation, audio/visual web based submission, an A1 poster as well as an electronic poster, either a written report(or theses), or a 'paper' suitably formatted for a conference submission together with a laboratory log book (e.g., Snaveley and Wright, 2003).

The variety of assessment techniques utilised comprise: peer assessment of oral presentations, "ranking" of posters, all three items is varied. Students "vote" on each others' e-posters. The assessment of the written theses or "papers" is inherently difficult. It is not unusual to have large discrepancies between thesis/paper examiners; - it happens all the time in Master's and PhD theses - ultimately, any assessment of such documents has a degree of subjectivity (e.g., Webster et al, 2000, Ostheimer and White, 2005, Brodeur, 2002). However, because of academic requirements for a numerical mark, a simple numerical average is determined for the theses. This mark is then summed with the remaining marks for the portfolio artefacts from the two stages and a 'final' number" is obtained. This is not an altogether satisfactory outcome; since there is not one satisfactory method for providing a numerical grade. It would be more appropriate to "rank" the theses and assign a 'comment' e.g. *satisfactory*, *cum laude*, *magna cum laude*, or *summa cum laude* (adequate, with honours, with great honours, and with greatest honours, respectively). This is similar to awarding overall honours in a full course.

## **Concluding Comments**

According to Paulson, Paulson and Meyer, (1991) "Portfolios offer a way of assessing student learning that is different than traditional methods". Portfolio assessment provides the teacher and students an opportunity to observe students in a broader context: taking risks, developing creative solutions, and learning to make judgments about their own performances."

The assessment process for capstone portfolio projects is ongoing and evolutionary, changing from year to year, from cohort to cohort. In order for thoughtful evaluation to take place, teachers must have multiple scoring strategies to evaluate students' progress. Criteria for assessment of a finished portfolio are extremely complex (e.g., Gulbahar and Tinmaz, 2006),). The final numerical assessment is only a compilation of numbers as required by university administration. In an industrial context, when project tenders are considered, there is only one winner, and final list and the also rans. It is proposed that in any student cohort competing for capstone project success, the portfolio be utilised as the prime criteria for assessment. And in the regard, only one project is assessed as the winner (achieving a *high distinction*) the short list (achieving a *distinction*) and the remainder achieving either a *credit* or *pass* grade, with associated numerical qualifications.

As the academic semesters progress, students and assessors work together to identify especially significant or important artefacts and processes to be captured in the portfolio. They work collaboratively to determine grades or scores to be assigned. Rubrics, rules, and differing scoring approaches are designed for a variety of portfolio components. In addition, letter grades might also be assigned, where appropriate. Finally, some form of oral discussion or investigation should be included as part of the summative evaluation process. This component should involve the student, teacher, and if possible, a panel of reviewers in a thoughtful exploration of the portfolio components, students' decision-making and evaluation processes related to artefact selection, and other relevant issues. There is no one area of our current approach to assessment and evaluation of student progress which appears to be satisfactory.

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