Using e-Portfolios to Integrate Reflective Practice with Experiential Learning in Engineering Teaching and Learning

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Abstract: Universities are increasingly developing new approaches to improved pedagogy through the use of technology. Collaborative learning environments support these endeavours with aspects such as learning matrices for workflow-based assessment and standard templates for the publication of assessed artifacts in e-portfolios. Methodologies based on the use of e-portfolios can now be implemented that strongly enhance the professional attributes of students and equip graduates with an accumulation of digital artifacts and reflections that demonstrates their achievements and emotional intelligence. The aim of the research outlined in this paper was to investigate appropriate models for collaborative learning and e-portfolios, particularly in terms of the use of workflow processes which integrate reflective practice with experiential learning activities. We find substantive support for developing Cuppola's Type 2 e-portfolios as a major tool in supporting practice-based educational programs.

Keywords: e-portfolio, collaboration, engineering, graduates, professions

Introduction

This research project at the University of Technology, Sydney (UTS) investigates best practices in e-portfolio systems that facilitate student and industry engagement in Engineering workplace internships and in professional practice. The project was jointly sponsored by the Faculties of Engineering, Business and Information Technology at UTS, which are strongly committed to the concept of practice-based education and have woven this deeply into their undergraduate courses. It is a significant distinguishing characteristic of their programs and plays a major role in establishing a uniqueness which is seen by many students as the defining element in their choice of degree program, and by many employers as a key strength of our graduates.

Each Faculties' intern placements increase the graduates' preparedness to pursue successful careers in a changing professional workplace. For example, the UTS Faculty of Engineering has a strong practice focus which deeply permeates its teaching, research and professional activities. The UTS Engineering flagship undergraduate degree program incorporates two six-month periods of internship in industry – working with, and often as, professional engineers. These internships offer real-world experience and the opportunity to develop applied knowledge..

Given our strong focus on practice-based education, we are particularly interested in how to enhance the learning that emerges from practice – which includes aspects such as the design of the experience, and the nature of reflection on practice. Within our research project mandate, we aimed to actively investigate the type and extent of learning support provided by the features of existing major e-portfolio systems. This included communicating to students,

accessing by students, maintaining a learning matrix, students reflecting, collecting assignments, publishing an analytical report, utilising group collaboration tools and staff mentoring.

We adopted an action based approach that intensively tested the design of e-portfolios incorporating workflow support for reflection against defined graduate attributes. Although exploratory and pathfinding in nature, we were confident that actually using e-portfolios in a real subject would deliver the greatest insights for future implementations.

Background

The benefits of e-portfolios where students can collect, reflect, select and publish (Coppola 2006) have long been recognised by universities.

Arguably one of the major quests in teaching and learning is to understand how e-portfolios can be leveraged in such a way that students demonstrate the sort of emotional intelligence across the whole of their degree course that they most clearly achieve through internships in the workplace. (Johnston 2007; Scott and Yates 2002; Moulton and Lowe 2005) Our approach was to investigate this situation from the bottom up, starting with the real needs of interns that have practically emerged from student workplace experiences.
 The major change in technology that facilitates e-portfolios is the advent of Web-based collaborative learning environments (CLEs). The term CLE emphasises collaboration but is somewhat interchangeable with Virtual Learning Systems (VLEs) and Learning Management Systems (LMS).

Along with this new focus on collaboration has come a realisation that e-portfolios are actually a process, as distinct to artefacts such as online resumes which are merely snapshots. Coppola has recently proposed the classification of modern web-based portfolios into three different types: (adapted from Batson 2007)

1. Type 1 – self representational portfolios, such as an electronic scrapbook, personal space for expression like a blog or an artist's portfolio. Sometimes called a showcase portfolio. When companies use this sort of passive e-portfolio it is colloquially known as brochureware

2. Type 2 – pedagogically focused web applications that employ specially designed workflow processes to align experiential learning activities with outcomes and seek to integrate reflective practice. These types of portfolios often extend well beyond a particular subject to integrate the student's graduate attribute achievements across many subjects as well as during intern co-curricular and graduate professional experience. Perhaps most important of all, students can commence a professional record (often as a blog) that may become the centrepiece of their future professional life and employment prospects. In some learning institutions, these portfolios are expected to have a life of considerably more than 5 years. In the UK and Europe, reflective portfolios are also called Personal Development Planning portfolios (PDPs).

3. Type 3 – portfolios for assessment, analysis of performance and reporting for certification purposes. These portfolios are used to assemble evidence of specialist know-how and competencies for some form of accreditation. The recent phenomenon of corporate governance has led professional societies to develop complex requirements for evidence-based accreditation. In responding to this, students have devalued passive Type 1 portfolios and look to active, workflow-based Type 2 portfolios as a means to achieving their specific professional Type 3 portfolio. The concept of an e-portfolio-passport of experience and evidence-based competencies has already taken root in Europe and is very much on the Australian Government's educational agenda.

In our research project, we focussed on Type 2 e-portfolios. Workflows were established to facilitate students building content for their e-portfolios directed at employment and in some cases Type 3 e-portfolio certification. The content that is arranged to form the e-portfolio emerges from a number of assignments that are carefully crafted to evoke specific real-world experiences in self and peer learning.

Developing student graduate attributes using e-portfolios

Graduate Attributes is a term used to describe the inventory of professional skills and competences in which graduates of a University are expected to have developed general proficiency. However, the richness and diversity of

the human condition means there are many Graduate Attributes that may be used to characterise experience.
Our unique approach to graduate attributes in this research project is based on an existential view that students are at university to learn to be and especially to overcome anxiety in their professional and personal lives. Graduate Attributes are not just competencies and skills but modes of self-behaviour driven by underlying modes of thought.

The existential model suggests that the best way for students to gain Graduate Attributes is to experience real world events and engage in those events. Therefore, the role of subject designers is to provide challenges that evoke experiences such as communication and critical thinking. By extension, the role of degree course designers is to ensure that the range of subjects provide all the experiences necessary for the student to develop real experience in the graduate attributes.

The outcome for students is a published e-portfolio that can be seen as a very large, detailed, personalised and reflective resume indexed by Graduate Attributes, with a student's traditional black letter resume as a PDF file at its core. This can have a powerful effect on the reader because of the reader's proximity to the native, self-effacing and often innocent (in the sense of untainted by any agenda) thoughts in a student's mind.

Selection of CLE for research project

A collaborative learning environment is special resource-integrating environment in which the students are immersed by carefully directed student experience tasks and assessments throughout every part of their learning and emotional intelligence development. This environment then persists as a dynamic repository of jewels of experience, achievements and reflections that that illustrates the student's educational, certification and life journey[1].
In this resource-integrating environment:

- workflows exist that become part of the pedagogical design and execution of subjects and courses
- social networking and other tools exist that facilitate student collaboration
- reflection and evidence-based digital artefacts of student experience items are accumulated through subject and workplace interaction (Lorenzo and Ittelson 2005)
- templates exist that lecturers and students deploy to present the digital artefacts for various purposes, such as subject assessment, resumes and professional accreditation
- students have a reliable long term publishing location where they can present their learning journey and evidence of their abilities over many years and phases of their career (Butler 2006).

We investigated sixty e-portfolio systems through literature research, practical trials where feasible and interviews with staff across multiple universities. With only limited resources to undertake broad trials, we focused on the Sakai CLE because the other e-portfolio software we investigated did not facilitate the full cycle of our conceptual model. The key reasons we chose the e-portfolio systems within Sakai for our research project are that Sakai is:

- the host for the Open Source Portfolio (OSP). One of the most clear differentiations of this environment is that it facilitates all three of Type 1, 2 & 3 e-portfolios
- that it was developed by universities for universities and is actively maintained by universities
- a modern, highly scalable Service Oriented Architecture
- highly regarded and used by 9 of the world's top 14 universities and has an impressive list of over 100 financial supporters (Sakai 2007), including a number of key players in the field
- a collaborative learning system, which is a key area of interest for internships
- a framework for building collaborative tools and UTS is interested in adding two recently developed self and peer assessment tools
- may now be interfaced to networking tools like Facebook to provide an area for employers to browse that is appropriately separated from an individual's private life (Koopal 2008)
- a community of passionate and pedagogically switched-on people in universities and proper governance and stewardship through a Foundation

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[1] A Korean proverb often referred to observes that All the beautiful pearls in the world won't make a necklace until you string them together. It emphasises that individual experiences need to organised and related to each other.

Method

The key tasks undertaken in this research project were:

1. Review of current e-portfolio literature and best practice
2. Development of a conceptual pedagogical model for discussion with Faculty stakeholders
3. Interviews with major stakeholders in the Faculties of Engineering, Business, IT, Science, Law, Nursing & Midwifery, Careers Service and UTS' Interactive Media Learning department
4. Interviews with other Australian universities including the Queensland University of Technology, the Australian National University and Charles Sturt University
5. Implementation of the Sakai CLE on the Faculty of Engineering's Sun-server cluster, together with authentication from the University's LDAP server
6. Implementation of e-portfolios within the 5 subjects of Engineering Economics & Finance, Engineering Project Management, Engineering Professional Practice 1 & 2 and Information, Computers & Telecommunications Design. In aggregate, almost 1,000 students were introduced to e-portfolios through lectures, tutorials, online screenshot workthroughs and help-desk support
7. Development of an e-portfolio (a system of XML forms, XSLT transformation templates, learning matrix submission and assessment practices and associated workflows) for assessment
8. Integration of e-portfolios for assessment in Engineering Economics and Finance in Spring semester 2007
9. Three surveys of student attitudes to Sakai and e-portfolios
10. Statistical and factor analysis of the three surveys using the open source statistical suite R packages factanal and psych. We ensured that Factors were orthogonal (independent of each other) by applying the mathematical technique of Varimax rotation. The reliability of factor analysis in our exploratory analysis was checked by calculating Cronbach's Alpha and McDonald's Omega Saturation Co-efficient.
11. Preliminary presentation of the Engineering Economics and Finance e-portfolio structure and indicative results to sixteen Australian and international universities at the ANU Sakai Conference in November 2007

Student surveys

The objective of the Surveys was to investigate the use of an e-portfolio tool and to measure the benefits to students of both e-portfolios in general and the particular e-portfolio implementation in Sakai in particular; and to investigate Sakai's collaborative functionality in facilitating communication and collaboration in academic studies.

Our experimental design did not permit parallel surveys using a control group (i.e. a group that did not experience e-portfolios). Therefore we adopted a series of 3 surveys of the same students before, during and after their e-portfolio experience. This has provided an internally consistent set of data together with a more complete understanding of how the views of students and the underlining factors changed over time. For example, in one survey themes combine as a single factor while in the next survey the themes separate into independent or orthogonal factors.

Surveys were conducted at the commencement of the semester (after students had been initially introduced to Sakai but before they had experienced the e-portfolio tool), during mid-semester (after one real-world experience task) and at the end of semester after four major items of real-world e-portfolio content had been prepared by all students and submitted for assessment.

Findings

Faculty interviews

Our Faculty interviews introduced us to many common themes on reflection in learning, course improvement, online group collaboration and graduate attributes across various Faculties at UTS. We found there had already been some excellent work done in some Faculties and also noted specific themes were emerging, such as encouraging law students to self-assess their mental health.

It was widely believed that the pedagogical benefits of e-portfolios could be significant in improving both
- communication and monitoring in professional placement programs, and
- the collection and reflection of learning longitudinally throughout entire degree programs.

During the interviews a number of Faculty staff indicated a keen interest in adapting the results of the research project to their Faculty, given the necessary time, right templates and appropriate IT support.

The main areas of concern in regard to e-portfolios related to:

- the difficulty of practically realising the benefits of e-portfolios given the need for Faculty staff to learn dramatically new approaches in experiential learning involving the evoking of graduate attributes, particularly as in most cases graduate attributes are still not fully defined
- time and money costs and the possibly serious implications for students and staff of getting things wrong
- implementation problems
- the need for support from the top of the university so Faculties would not be on their own and perhaps developing isolated systems
- being at a loss to know where to start given a general lack of tools and IT support, particularly as so many other universities are already using a dazzling array of tools to pursue many diverse strategies

Student Surveys

Surveys were voluntarily requested from a cohort of 140 students in the Engineering late-stage undergraduate course Engineering Economics and Finance.

	Survey 1	Survey 2	Survey 3
Survey time	Beginning of semester	Middle of semester	End of semester
Instructional Support	Lecture on e-portfolios	Tutorial on Sakai	Extensive mentoring
Assignments requiring reflections	None completed	One completed	Three completed
Full e-portfolio developed including "About me", resume	Not required	Optional	Compulsory
Number of voluntary responses	65	95	96
Correlation cut-off for 1% confidence level	± 0.328	± 0.272	± 0.272
Variance explained by 5 Factors	32.5%	31.7%	35.1%
Cronbach's Alpha for 5 Factors	0.73	0.77	0.81
Omega Saturation for 5 Factors	0.35	0.62	0.48

Table 1: Summary of Student Surveys

Additional questions were added to each of Survey 2 and 3, after analysis of the previous surveys indicated a need for further insight. As a result, each of the three e-portfolio surveys had greater than 45 questions, with survey 3 having nearly 70 questions. However, our statistical analysis concentrates on those questions common to all three surveys. We found that five Factors in each survey were optimal in explaining the variance in student answers in the questions that were common to all three surveys.

Table 1 shows Cronbach's alpha ranging from 0.73 to 0.81. An alpha above 0.6 is regarded as satisfactory and above 0.8 as indicating good reliability.

Omega Saturation in the three surveys ranges from 0.35 to 0.62. Values of 0.50 or more are regarded as indicating coherency. On this measure, Survey 2 is satisfactory and Survey 3 is marginally satisfactory. The low coherence of Survey 1 reflects the students' incipient awareness of the Sakai and e-portfolio systems. While we have not provided the data here, a satisfactory result is also shown when all surveys are combined, with individual student responses linked across surveys and a time dimension introduced.

5 Factors for Survey 1

Context of Survey	A survey completed shortly after students attended a preliminary lecture on e-portfolios
Factor 1	e-portfolios benefit employability is the dominant factor and explains 11.3% of survey variance
Factor 2	Sakai assists communication and group collaboration explains 6% of the variance. Little differentiation is made between communication tools and collaboration tools (e.g. group sites)
Factor 3	Convenience for part-time students
Factor 4	Student software experience. We found some students have significantly greater software tool experience than others. This factor is generally uncorrelated indicating that previous software experience does not affect each student's adoption of Sakai and e-portfolios
Factor 5	That Sakai enhances elearning explains only 3.9% of the variance in the survey answers. In this first survey, students haven't developed a strong opinion on the use of Sakai

Five Factors for Survey 2

Context of Survey	Survey completed shortly after students submitted the first student experience item for their e-portfolio comprising individual reflections on achievements and transferable skills. The majority of student groups had set up a collaboration site for this assignment, albeit with use ranging from extensive (i.e. announcements, wiki, blogs, chats and forums) to minor
Factor 1	Sakai is quality e-portfolio & elearning tool explains 7.9% of the survey variance. Students rate the Sakai e-portfolio tool and whole Sakai environment similarly but the benefits of each are assessed differently
Factor 2	e-portfolios benefit employability drops from first to second ranking although it explains 7.8% of the variance, which is approximately the same as Factor 1. In this survey, students appear to differentiate between the benefits of e-portfolios generally and the benefits of Sakai tool
Factor 3	Student software experience as in Survey 1
Factor 4	Sakai assists communication and group collaboration as in Survey 1
Factor 5	Convenience for part-time students as in Survey 1

Five Factors for Survey 3

Context of Survey	A survey completed shortly after students had submitted a three student experience items for their e-portfolios, their final polished e-portfolio, comprising individual reflections on achievements and transferable skills, and an "About Me" page with a resume
Factor 1	e-portfolios benefit employability explains 13.8% of the variance. Students rate the Sakai e-portfolio tool and the benefits of e-portfolios similarly
Factor 2	Sakai enhances elearning & communication, which explains 5.9% of the variance. Students rate elearning tools (such as announcements) and communications tools (such as chat) similarly
Factor 3	Student software experience as in Surveys 1 & 2
Factor 4	Convenience for part-time students as in Surveys 1 & 2
Factor 5	Sakai enhances Group Collaboration. The Wiki appears in this survey as students differentiate communication tools that can be used for student-teacher communication from group collaboration tools for intra-group communication. In the previous two surveys, Sakai assists communication and group collaboration comprised one factor

We found that student perceptions of Sakai and e-portfolios changed over time as students started to know what the systems could do for them and saw the practical purpose of group collaboration, reflective learning and e-portfolio content. The changes from the mid-term Survey 2 to the end of semester Survey 3 conclusively demonstrate that students increasingly believe the Sakai e-portfolio tool delivers the benefits of e-portfolios and that Sakai communication tools enhance learning.
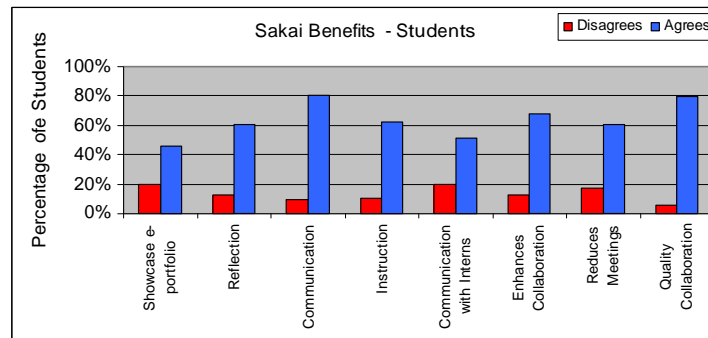

Figure 1: Student perceptions of Sakai benefits

Analysis of our student surveys led to an understanding of how the Factors changed ranking and sometimes changed in the mix of underlying themes. The following diagram sets out our understanding of these phenomena.
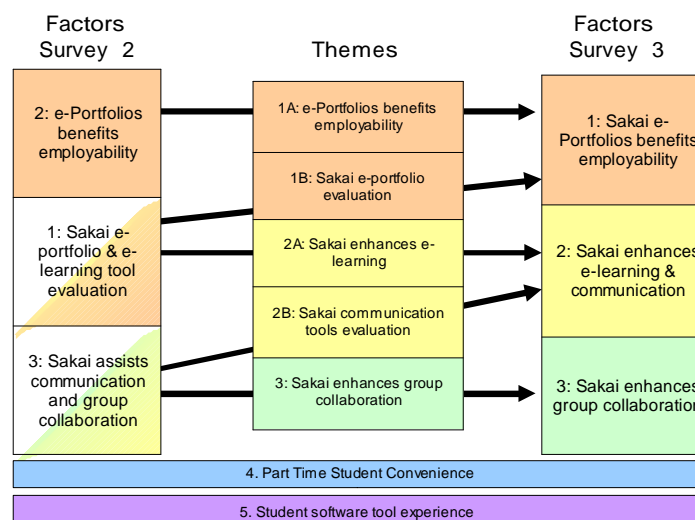

Figure 2: Explaining Themes from Factors in Surveys 2 & 3

Throughout the semester students became more positive about the Sakai tools including e-portfolio, elearning, communication and group collaboration. By the third survey:

- 89.6% of students indicated e-portfolios were very or often useful, useful or occasionally useful
- 95% of students indicated Sakai is useful and 69% believe Sakai has benefits over Blackboard
- 79% of students believe Sakai improves the quality group collaboration. Based on an special audit we conducted, there appears to be a positive correlation of 33% between achieved marks and group

collaboration

- Although the course Engineering Economics and Finance is not an internship subject, many students have previously undertaken internships or will undertake internships in the ensuing semesters. We asked whether Sakai would be useful for Faculty staff to communicate with interns and 51% of students surveyed agreed.
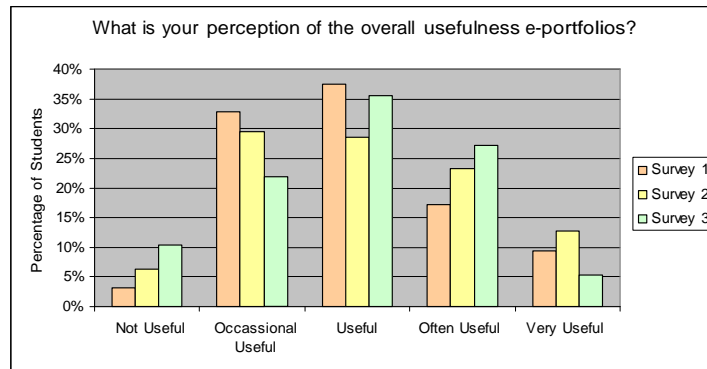

Figure 3: Student perceptions of ePortfolio usefulness

Discussion and Conclusion

Students have found that e-portfolios have large benefits for them, are easy to use, and that Sakai is very feature rich, reliable and not difficult to use. Students recognise the growing workplace demand for transferable skills. Across the three surveys, the most important theme influencing a student's answers is that Sakai and the e-portfolio maximises a student's ability to articulate evidence of graduate attributes for employability. The discovery that students see the reflective e-portfolios as benefiting their employability suggests that any e-portfolio implementation needs to be primarily focused on enhancing professional skills of the students for employability or certification.

In conclusion, this research project has:

- clearly demonstrated the pedagogical benefits of Type 2 reflective, assessable e-portfolios for students
- found that students are very keen to use e-portfolios to accumulate reflective learning with evidence for presentation to employers and professional societies
- found that Faculty staff see the potential for e-portfolios as exciting and at times intriguing
- developed many valuable insights into the Sakai collaborative learning environment to enhance communication, collaboration and elearning, and provides part-time students with improved flexibility
- found substantive support for developing Type 2 & 3 e-portfolios as a major new strategic direction for differentiating practice based universities such as UTS
- developed a basis for additional pedagogical and strategic research into Type 2 & 3 e-portfolios utilising this pathfinder project as a guide for enhanced experimental design
- determined the scope of resources and leadership required to implement e-portfolios in a subject or course
- with core capability in Engineering Economics and Finance, positioned UTS as early adopter in the field

There are clear implications for the strategy of universities:

- e-portfolios are the future of universities. A time is approaching when students e-portfolios will be more important than the university's brand and academic transcript grades. At that time the main role of a university will be to develop students through a tapestry of specific graduate attribute evoking experiences and presentation of reflective teaching and learning in e-portfolios
- a significant investment is needed for a university to become a leader in the field. In the case of an open source application such as Sakai, this is not for the sticker price of the software. The significant investment is for change management in teaching and learning. Faculties need to define quality of service to students in the context of equipping students with e-portfolios and map how graduate attributes will be evoked

across courses. Each Faculty will require its own e-portfolio templates and workflows for integrating assessment. Academic staff then need to be trained in the effective use of e-portfolios in experiential and reflective learning.

Acknowledgements

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