Engaging engineering students in learning how to successfully communicate research plans

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This paper describes an assessment strategy used to engage students in their learning in an engineering research methods course. This strategy drew on the expertise of engineering faculty (content specialists) and learning advisers (academic skills specialists). The paper evaluates the effect of a change in course assessment processes from a set of disparate assignments related to generic research skills, to a set of discipline specific scaffolded assignments which built toward the capstone assignment – the research proposal. We determined that a scaffolded curriculum design and embedded academic skills development - focusing all activities of the research proposal - resulted in better outcomes and a stronger engagement of students with their learning than prior cohorts who did not have the same support.

Keywords: *Engage, discipline, embed, scaffold, assessment*

Introduction

This paper documents the assessment innovation which took place in Engineering Research Practice (ERP) over a two year period to address the need to strengthen students' abilities to produce a cogent research proposal. What is unique about this particular group of students is the fact that the majority are:

- International with English as a second language
- Articulating from exam-rich backgrounds to a language-rich course.

The generic skills of Australian graduates have drawn much criticism in the past half-decade with particular attention drawn to the disparity between graduates' skills and industry demand (Borthwick & Wissler, 2003). Knight (2002) highlights how employers value communication skills above all. This is echoed by the various engineering professional bodies including the defence industry in South Australia which expresses typical concern that tertiary graduates exhibit limited ability in written communication (Sitnikova , 2007).

According to Wlodkowski (1999) engaging students in their studies is predicated on giving the student the necessary support to make the learning achievable, combined with choice over what they learn and enough challenge to make the task enjoyable. The task of writing a research proposal is a deeply personal one which, although aimed to prepare students for their professional discipline, is embedded in what students believe and enjoy. Duff et al (2006)

found academic integrity (referencing and its mechanics) a vexing issue for students articulating from one culture to another. They also found engineering students who enter postgraduate courses often have little exposure to electronic databases for research or basic generic academic skills such as report writing.

This paper discusses the effect of two major innovations in the course ERP to engage students in their learning and to develop their communication and academic skills more fully. The first of these is to change the approach to assessment (discipline content) and the second is to 'companion' assessment with the strengthening of academic and communication skills (generic). Each of these approaches provides the support, challenge and choice and therefore maximises student engagement with their learning (Biggs 1999, 2008; Vygotsky 1978, 2002; Wlodkowski 1999).

## The challenge, the support and the choice

The ERP curriculum provides scaffolded assessment (Vygotsky, 1978, 2002). Each assessment task in ERP builds on the previous to produce a cogent research proposal (the third task). The 'nesting' approach enables students to build on assessment feedback on their first two assignments to improve their marks. This assists the students to develop their understanding and articulation of traditionally challenging tasks - goals of their research, the problem, sub-problems, literature review and methodology. The scaffolding of assessment tasks builds on the Vygotskyian pedagogical perspective of building a piece of work through the preparation of 'portions' of the task to assist learner readiness (Vygotsky, 1978, 2002). This involves formative assessment tasks and it is expected that the students respond to feedback to build a finished product.

A description of scaffolding applied to engineering education is provided by La Branache (2006) who uses this constructivist technique to assist engineering students to cope with dense academic readings. La Branache proffers one definition where scaffolding is a 'structural approach' where students are supported through the incremental learning of complex concepts in a classroom setting.

The embedding of generic academic skills provides a second dimension of support. The emphasis on embedding the development of generic, as well as discipline specific, skills within the disciplinary context is a common practice at the University of South Australia (UniSA).. The most effective development of generic skills occurs when these skills are embedded in curricula in a way in which students can see them as relevant to the disciplinary context (Hicks et al., 1999; Loads, 2007; Unviersity of Woolongong, 2005, Skillen et al.,1998). This makes the skills more relevant and the learning authentic than if they are taught in isolation. The approach recognises that there is a particular 'culture' of academic writing which, according to Pea in O'Neill (2001), must be learned in a discipline specific context.

Figure 1 shows the interplay between discipline context (the lectures) and generic skills (the workshops) and assessment which generates a cycle of continuous development. Each

element is inseparable and contingent upon the other.
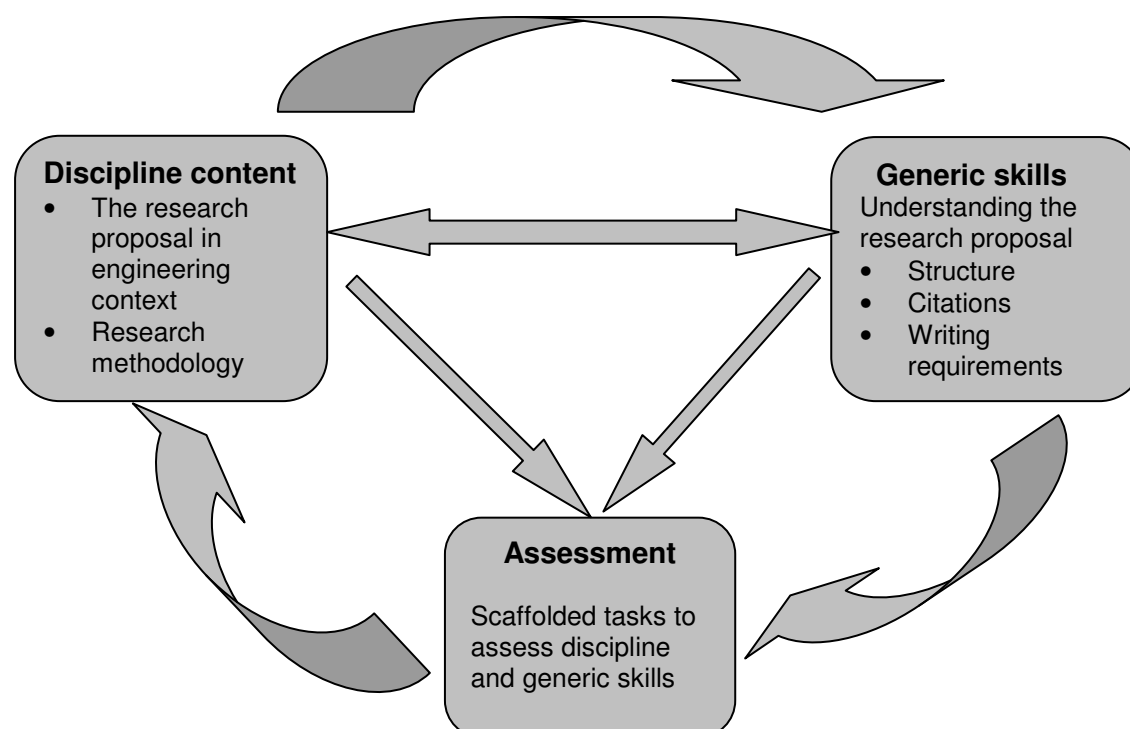
Figure 1: Cycle of academic development in ERP.

Biggs (1999, 2008) argues that in order for students to succeed, they need to see that the tasks are valuable and therefore meaningful. They must also be supported towards this success in order to maintain motivation. Ultimately, the aim of the teaching staff was to foster the written skills which would enable the student to clearly articulate a statement of goal and methodology for a piece of research to clearly communicate the conceptualisation of a task. Table 1 shows how assessment tasks were structured 2005 and 2006 to develop generic and discipline specific skills which led students through to the generation of their research proposals.

This paper compares two different methods of running the course the first of these methods required students to write five preparatory assignments. The second of these methods was a modification to the first one which saw a reduction to two preparatory assignments. In each case, the preparatory assignments led to the research proposal – the 'capstone project'.

A major difference was that in 2005 the five assignments in the first method were all focused on development of generic skills related to research proposals and planning (write a summary; write a paraphrase). In this approach students were somewhat disembodied from the final project.

In 2006, this approach was disbanded and students were required to do two preparatory assignments which built on and led them through to writing their research proposal. Significantly, all aspects of the proposal revolved around the student's *own* choice of topic.

Table 1: Two different methods of assessment tasks, weightings and generic skills used in ERP in 2005 and 2006

Year	Item	Disciplinary skills within assessment item	Weight	Generic skills
2005	1	Statement of problems and sub-problems	5%	
	2	Qualitative/quantitative analysis of a topic	5%	
	3	Statistical analysis of data sets	5%	
	4	Critique of a research proposal	5%	
	5	Literature review (set topic)	20%	Searching library databases Referencing and academic Integrity Writing the literature review
	6	Research proposal	60%	Three informal Writers' Circles
2006	1	Research problem, sub-problems, explanation, background and significance	20%	Narrowing the topic
	2	Methodology, schedule, literature review	20%	Searching library databases Referencing and academic Integrity Writing the literature Review
	3	Research proposal, adding explanation of how success would satisfy the requirements for thesis assessment (at the level targeted by the student)	60%	Writing the research proposal (electronic resource) (Connection, 2006) Two informal Writers' Circles workshops

Study methodology

In 2005 and 2006 the course was taught twice, once with Ferris and once with Sitnikova as course coordinators.

In 2005 students submitted 6 discrete assessment items. The intention of the first five 'preparatory' assignments was to develop student skills and ability to write of the final assignment - the research proposal. These skills included:

- identification of a research problem and sub-problems
- classification of a research problem as quantitative or qualitative
- writing a literature review of a particular set of papers
- performing a set-piece statistical analysis
- critiquing a sample research proposal.

In the assessment of the research proposal, it was found that students did not make the constructive link between the earlier, skills development, assignments and the skills required in their capstone research proposal assignment. For example, the students had not learned how to link their research problem to a methodology, nor how to use the literature review to make a case for their proposed research. Therefore, we concluded that the course was unsuccessful in achieving the purpose for which we had established it and needed to be

restructured. This led us to seek a more effective way to construct the link between the earlier, formative work and the final assignment.

The experience of student performance in 2005, described statistically in Table 2, caused us to introduce a new teaching approach to scaffold and align assessment with the final research proposal so that the necessary support was provided Biggs (1999, 2008).

Table 2: Assessments Average Results for the four offers of the course

	Sem1 2005	Sem2 2005	Sem1 2006	Sem2 2006	All 2005	All 2006
Res Prop	51.192	55.617	64.631	65.275	53.116	64.991
$Res\_Prop - Ave\_Prep\_Ass$	-19.167	-8.758	2.842	9.296	-12.215	6.444
Ave Prep Ass	68.181	61.625	61.789	55.979	65.331	58.547
Total	57.988	58.020	63.495	61.557	58.174	62.372

By contrast, in 2006, both offers of the course required students to produce only two preparatory assignments, each of which was designed to be a part of the capstone research proposal. These two assignments, in turn develop the skills of:
- identifying the research problem and sub-problems, describing the background to the project and its significance
- preparing a methodology, schedule and literature review for the proposed project.

This combination of assignments was designed to be formative, with assessment feedback building on the nascent writing and skills of the students – recognising that many would struggle with writing in English. The results described in the next section demonstrate how individual performance improved relative to the earlier assignments, indicating improved achievement of the principal objectives of the course.

Alongside the discipline-centric material, generic skills were taught by a learning adviser, Duff, and by academic librarians. Table 1 shows the difference in the assessment structure and the development of new generic workshops and resources between 2005 and 2006. One of these resources (an online workshop) for example, was aimed to develop students' ability to both understand the language and purpose of the sections and narrow their research topic. A novel click-through triangle showed students a way to make their research feasible. This triangle helped students to narrow their research topic as they click through a broad topic to more specific iterations

The total number of students in all classes (two years, four study periods) was 181. Of the 181 students, 75% studied the course in 2005 (see Table3). The use of the grid structure for the comparison of results will assist in highlighting the differences achieved through the two assessment methods. It is now widely used by engineering students at UniSA.

Table 3: Offers of the course investigated in this study

Year	Semester 1 Course coordinator FERRIS	Semester 2 Course coordinator SITNIKOVA
2005	78 (71 international, 7 local) students completed 5 preparatory assignments and research proposal	60 (54 international, 6 local) students completed 5 preparatory assignments and research proposal
2006	19 (16 international, 3 local) students completed 2 preparatory assignments and research proposal	24 (19 international, 5 local) students completed 2 preparatory assignments and research proposal

Results

The average result of assessments is summarised in Table 2, above. This table shows that both the average mark for the research proposal assignment and the total mark in the 2006 was better than 2005. Also, the results for the comparison of the research proposal and the average for the preparatory assignments, being $Re s\_ \Pr op - Ave\_ \Pr ep\_ Ass$ for both course offers, Semester 1 and Semester 2, in 2006 are positive numbers while the results for 2005 runs are both negative. This result indicates that after introduction of the new assessment method students achieved better preparation for the final assignment through the preparatory assignments that they had achieved with the original assessment arrangements.

This result indicates a greater level of achievement in student work using the scaffolded approach. It may also indicate that the addition of generic resources (such as the 'Narrowing the Topic' and 'Writing the research proposal') has impacted on the positive result. These resources were commensurately developed with the refinement of the assessment.

It is interesting to note that the average of the results achieved in the preparatory assignments in 2005 were considerably greater than in 2006 and that the same relative average results were achieved in a comparison of each semester with the equivalent semester in the other year. This finding indicates that the smaller number of assessments explicitly designed in a constructive sequence were more effective in developing student knowledge of the objectives of the course than the relatively easier and larger set of assignments that attempted to teach the skills generically. This finding also indicates that the constructive arrangement of the assignment forced students to confront the difficult issues of formulating a coherent plan for research in the formative assignment stages of the course, rather than in the capstone assignment, as was the case with the 2005 assessment arrangements. Students found significant difficulty with the tasks associated with writing the research proposal, but were able to learn through a single round of individualised feedback provided on their individual attempt to perform the task.

A more detailed statistical analysis has been done for this study using both the t-test and ANOVA. The result of this study is presented in Table 4.

Table 4 Outcomes of statistical analysis of the results

Class sets compared	t-test: paired samples		ANOVA: single factor	
	t Stat	t Critical	F	F Critical
Sem1 2005 & Sem1 2006	-6.139	2.056	40.195	3.941
Sem2 2005 & Sem2 2006	-5.998	1.994	23.153	3.957
All 2005 & All 2006	-9.054	1.986	62.004	3.894

The t-test has been run for paired samples of data comparing the original assessment arrangement case, 2005, and the modified assessment case, 2006. The test was run on the NULL hypotheses that there was no significant difference in the results achieved in the two assessment situations. The result shows that at the 0.05 level of significance in each of the three cases $|t_{Statistic}| > t_{Critical}$ showing that there was a significant difference between the paired samples. The hypothesis that there is no difference between the cases is rejected.

The ANOVA single factor results confirm the conclusion from the t-test analysis, above. At the 0.05 level of significance, for all cases, $F > F_{Critical}$.

Discussion

Through the study of our offers of ERP, and the emphasis on the development of discipline contextualised communication skills, this paper argues that the engineering educator's responsibility is to maximise opportunities for student engagement with the curriculum. In doing this, the teacher better equips students for developing projects and proposals in their careers. ERP is a course concerning the discipline-focused matter of research methods. This is a new skill for the students enrolling in the course and one which is potentially daunting.

 The abstractions of what constitutes an appropriate research question and proposal are difficult for students to engage with. The problems with the first proposal in 2005 contributed to the restructuring of assessment in 2006 through extensive, scaffolded and individualised feedback on each assessment task combined with embedding generic skills and language support.

A second driving force in the revision of the assessment was our belief in a very deep connection between knowledge of discipline specific matter and the ability to conceptualise this knowledge so that others can see its importance and share its meaning. This involves the fostering of higher-order thinking skills and students need to be supported in order to achieve and articulate these.   This was achieved by fostering communication skills within discipline-specific context - balancing engineering discourse with clear, generic communication skills. Engaging students in these areas, in turn, enables students to engage more fully with the requirements of their profession. This is especially important because many of the students have articulated from teaching, learning and assessment cultures (Duff et al, 2006). Prior to the interventions, students were required to learn broad variety of skills simultaneously without support structures upon which build.

The responsibility of engineering educators to equip students to become good communicators within their field is constantly reinforced in engineering education and professional literature (Sitnikova et al 2007; Vest, Long, Thomas, & Palmquist 1995; Walker 1999). The goal of the

teaching and assessment modifications to ERP was to improve the capability of the students in the task of identifying, planning and communicating a prospective research project. Although these tasks are formulated as academic tasks, they bear a close relationship to the kind of responsibilities for which professional engineers are employed. The tasks performed by engineers include the identification, planning and proposal development work associated with engineering projects - tasks which are clearly analogous. Therefore the skills developed in the ERP research proposal are also generic, work relevant skills. This goes some way toward closing the nexus between university study and industry demands of graduates.

The student results achieved through the two approaches in ERP (one without scaffolded approaches to assessment, and one with) indicate that the students have benefited significantly from the close linking of the assignment tasks in the constructive formulation of the curriculum. These results demonstrate a significant improvement in the course to achieve its immediate academic objectives of teaching students to develop a sound proposal for a piece of planned research.

Conclusions

Through a long process of reflection, the authors have fine-tuned an approach to teaching which recognises that in order to create an engaging learning environment, the assessment must be relevant, supported and meaningful.

The approach presented in this paper demonstrates how scaffolding in assessment tasks and the embedding of generic skills development can foster clear communication of a research proposal or idea. The development of this skill is a small step towards building the professional communication skills required of engineering graduates. The improvement in student results indicates improved learning of both the communication of engineering plans and the process of making, formulating those plans – an important feat for a second-language learner or students who are more accustomed to exams than writing.

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