

# Building Graduate Capabilities to Communicate Research and Plans Successfully\*

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*This paper describes a strategy used to develop skills in research and communication among a cohort of postgraduate masters students. This took place in Engineering Research Practice (ERP), where most of the students were international with English as an additional language (EAL). The paper evaluates the combined effect of a change in course assessment processes and the introduction of a program of English for Academic purposes (EAP). We determined that tightly scaffolded curriculum and assessment design, combined with discipline-specific writing support, resulted in higher quality work.*

**Keywords:** engineering research methods; scaffolded assessment; communication skills; international students

## 1. INTRODUCTION

ENGINEERING RESEARCH PRACTICE (ERP) is a course taught at the University of South Australia primarily for masters students. The course is unique, as it introduces students to a wide range of possible research methodologies, both quantitative and qualitative. Some of these methodologies are traditional in engineering, such as experiments characterizing part performance, and some are less traditional, such as scholarship and action research [1]. The goal of ERP is for the students to be able to clearly articulate a statement of goal and methodology for their proposed research.

The profession of engineering requires its practitioners to have clear, systematic, persuasive and people-centred communication. These aspects of communication are central to the engineer's ability to negotiate and communicate research plans. Singh and Knight [2] highlight how employers value communication skills above all. The development of these skills starts with the engineering curriculum. The research proposal demands academic writing skills, including referencing and citation, as well as discipline contextualised generic skills such as clarity of expression of a plan for action. In careers, these skills are rewarded—not only with successful grant applications, but with regard to employment prospects.

Locke, Spirduso and Silverman [3] explain how the proposal:

. . . serves to communicate the investigator's research plans to those who provide consultation, give consent or disburse funds . . .

Further, they suggest that the level of support for a proposed piece of research, for example financial support, will all depend directly on the clarity and thoroughness of the proposal. Barrie [4] found generic skills assisted with the *translation* of concepts to a specialist audience. These skills were *complementary* to disciplinary knowledge and were *precursors* to learning in a discipline. These observations underline the need for an engineering curriculum to build sound writing skills in its graduates.

The communication 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 [5]. The concern is echoed by the engineering professional bodies, globally and Dukhan [6]—in working with undergraduate students—points to the increase in the demand by industry for finely honed communication and critical thinking skills. The concern of the South Australian defence industry, for example, is typical—tertiary graduates exhibit limited ability in written communication [7].

The goal of ERP is for students to produce a cogent and persuasive 'capstone' research propo-

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sal. The study presented here, examines the combination of assessment strategies and innovations to strengthen writing in the discipline where, for most of the students, English was an additional language (EAL). It shows the development of student work over a two to three year period and how this was supported by new approaches to assessment and English for Academic Purposes (EAP).

The objectives of the course (as cited on the course website) are to provide students 'with an understanding of what research is, and the various research methodologies [in order to] proceed to research projects in Engineering'. The textbook used for the course is Leedy and Ormrod's *Practical Research Planning and Design* [8]. Alongside of this, are a variety of language and learning resources to be discussed in more detail further in the paper.

To achieve the course objectives, students are required to produce a research proposal which will demonstrate the hallmarks of this particular genre which include:

- Being able to narrow down a topic to a scalable and viable research project.
- Demonstrate understanding of the problems and sub-problems arising from the research problem.
- Write a credible and critical literature review.

Alongside of this, students must demonstrate:

- Correct referencing technique.
- An understanding of the purpose of the sections
- Clear expression of their ideas.
- Excellent grammar and sentence level expression.

The first challenge facing both students and lecturers was the need to change assessment design. The course coordinators, Ferris and Sitnikova, had inherited a course design where the assessment tasks were intended to hone generic skills, such as writing a summary, citing a reference, or performing a statistical analysis. While useful in introducing foundational academic and research skills to the students, these tasks bore scant relation to the final task—the final research proposal.

Constructivist educational theorist, Lev Vygotsky explains that learning takes place in the Zone of Proximal Development where the learner must be developmentally ready to learn each new task [9, 10]. This development is assisted through careful scaffolding. A description of scaffolding applied to engineering education is provided by La Branache [11] 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 able to enhance their learning through the incremental learning of complex concepts in a classroom setting.

In addition, Biggs [12] underlines the importance of constructive alignment in assessment, where all

'teaching and learning should focus on the intended learning outcome' [12]. In other words, all roads should lead clearly and unambiguously to the ultimate goal—in this case to be able to produce a capstone research proposal which fosters the ability to communicate research and plans for that research successfully. This concept forms the key analogy for identifying other courses to which the method could be usefully applied. Aspects of this model have been applied in at least two other courses at UniSA.

The second challenge related to ongoing struggles facing the students with a new *culture* of writing, the genre of the research proposal, in a new *cultural setting*, in English, using different approaches to referencing. We note that all students, even graduates of our own University are confronting the research proposal as a new genre. In an earlier study with this cohort of students Duff et al. [13] found academic integrity, referencing and citation, were vexing issues for students articulating from one culture to another. Duff et al [13] also suggested engineering students articulating from *undergraduate* to *postgraduate* courses often have little exposure to electronic databases for research or basic generic academic skills such as report or proposal writing. Limited experience with academic skills is compounded by the fact that the ERP students articulate from exam and maths-rich backgrounds to a language rich setting, and from undergraduate to postgraduate engineering which requires writing a research proposal. In other words, students move from a quantitative, 'numbers-based' background to one which requires a more sophisticated use of written language to explain concepts and with emphasis on conceptual subtlety.

O'Neill, in drawing on the work of Flower and Hayes, [14] describes genre in scientific writing as a 'cultural community of practice' which includes writing 'customs' to enhance effectiveness. Hyland, in citing Kramsch and Connor, [15] points out linguistic and cultural differences do not often translate well into a second language, exacerbating a student's difficulties.

In order to weld together the links between assessment, English language support and understanding of genre within the discipline, an 'embedded' approach was taken. This approach is favoured by learning advisers at the University of South Australia [16].

From a pedagogical point-of-view, the researchers used three approaches. The first was to significantly alter approaches to assessment. Another was to strengthen language and academic support. A third, and related, approach was to collaborate closely with learning advisers and librarians—embedding workshops, learning support and research skills into the curriculum [17–19]. This would combine the teaching of discipline, engineering, content with co-curricular, academic and language skills within the discipline [20].

The course substance, learning to articulate a

Table 1. Towards a scaffolded approach in assessment and the embedding of English for academic purposes workshops and resources

Year	Item	Disciplinary skills within assessment item	Weight	English for academic purposes
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) [23].  Two informal Writers' Circles workshops.

plan for research, is new to all students—regardless of whether they are EAL or native English speakers. Whilst this paper concentrates on special needs of the majority cohort, EAL students, who comprise about 90% of enrolments, the constructive approach to assessment is useful for all students. The principles of good teaching are not necessarily culture bound—they apply universally [12].

The newness of the core course learning task, to articulate the design of a research project, enables all students in the course to derive significant benefit through the assessment process changes described.

## 2. STUDY METHODOLOGY

In order to strengthen the writing (and hence grades) of the ERP students, three approaches were taken: a redesign of assessment; development of English for Academic Purposes strategies and close collaboration between faculty and library.

The total number of students in all classes was 181. Across the two years, with a total of four study periods or semesters, the Course Coordinators, Sitnikova and Ferris, each taught an equal number of students. Of the 182 students, 75% studied the course in 2005, Table 2.\*

### 2.1 Scaffolded assessment

Changes were made to the assessment so that assignments were nested and sequential.

Prior to modifications in 2006 students were given six tasks which were tangential to the final research proposal. In 2006 a much tighter approach of three research proposal 'drafts' was adopted so that each assessment task in ERP built on the previous task to produce a cogent research proposal, the third task.

In 2005, the students were required to write *five* preparatory assignments followed by the research proposal. As Table 1 shows, these five assignments, while building useful generic skills, were disparate from the final proposal. As a result of this disparate and more generic approach, the students had not learned how to link their research problem to a methodology, or how to use the literature review to support the justification of the planned research.

In 2006, however, the students were required to write only *two* preparatory assignments. The students were required to produce drafts of their proposal which was not only more closely aligned to the final product, a cogent research proposal, but would enable students to focus and hone their *own* choice of topic. This would then take them further into their actual research projects toward the end of their master's degree.

The 'nesting' approach aimed to scaffold the student learning, and through formative feedback on their first two assignments, to improve their marks. The aim of this assessment was to develop a thorough understanding of the elements of a research proposal—the goals, problem, sub-problems, literature review and methodology.

This scaffolding of assessment tasks is built on the Vygotskyian pedagogical perspective of building a piece of work through the preparation of 'portions' of the task to assist learner readiness [9, 10]. The assessment tasks were required to be formative where students could respond to and

\* The difference in the number of students between the years was related to broader issues of changes in the total enrolment in the degree and changes in the degree rules; nothing specific to this course.

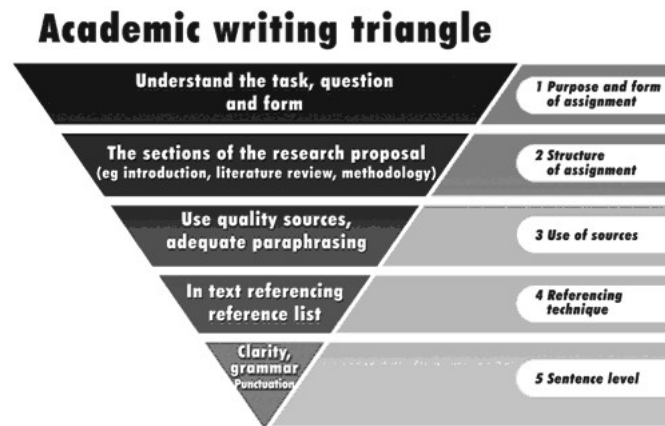


Fig. 1. The Academic Writing Triangle [21]

augment their earlier assignments to build a finished product. This was facilitated by margin annotations which were added electronically by the assessor. This assessment process is a critically important part of the course teaching because it provides students with feedback about their 'best effort' to do what they thought they had been taught. The students have the opportunity to correct their work in the final assessment task, and receive feedback on their revised work.

### 2.2 English for academic purposes

The language, cross cultural and academic skills dimensions were developed by a learning adviser, Duff, and library staff in close collaboration with ERP faculty so that they were aligned with the objectives of the course, the timing of assessment and, most importantly, the needs of the students. Fig. 1 shows the Academic Writing Triangle developed by the UniSA Learning Advisers [21] based on genre analysts Kaldor, Herriman and Rochecouste [22]. The triangle depicts the hierarchy of generic writing skills tailored to writing in the discipline. The first sections specify the requirements to understand the particular task, such as the research proposal. The second section refers in this instance to the need to understand the specific requirements of the sections. The final three sections, cannot be addressed until the first two are understood.

Students were taught how to use library databases in workshops by librarians, Duff and other Learning Advisers, the principles of referencing, using the often culturally alien Harvard system, and the function and language of the various sections of the proposal. Finally, sentence level aspects were addressed in informal Writers' Circles where students were invited to submit samples of their writing for peer review, to strengthen sentences and expression.

In addition, two online resources were provided. One was *Writing the Research Proposal* which provided the EAL students with handy

sentence 'fragments' which modelled the language of the literature review or methodology. The other was a 'click through' triangle, which was used as a tool to help narrow the research topic. The upside down triangle has five slices (similar in appearance to Fig. 1). It starts with the top slice (the broad topic) and as students click on a section, the next (progressively narrower) appears until the research topic is finely honed and doable. This 'narrowing the topic' resource was developed in consultation with lecturers and students who were proposing research topics which were unmanageably broad, such as how to increase the speed of the Internet!

Figure 2 depicts the pedagogy involved to achieve the course objectives and shows the close partnership between lecturers and Learning Advisers. Some of the discipline specific exercises completed in class included discussion of the methodologies that could be applied for particular student's research questions and prediction of the outcomes of a statistical game to develop intuitive feeling for the effect of statistics.

Lecture time (which was a two hour block, once a week) was shared with Learning Advisers who would often bring in samples of student writing, resources and referencing exercises to strengthen student approaches to their discipline specific work. For example, students were shown citations and asked to 'spot the plagiarism'. Sometimes they were given paragraph-long sentences and asked to simplify these. On another occasion, they were asked to map an approach to a literature review useful to one of the works-in-progress among the students in class.

Table 1 shows how EAL interventions occurred at several points during the study period, carefully positioned to coincide with assessment. In addition to the Writers' Circles toward the end of the assessment cycle, the students were given formal workshops and an online 'Writing the Research Proposal' resource. In some cases, students also sought individual consultations with both faculty

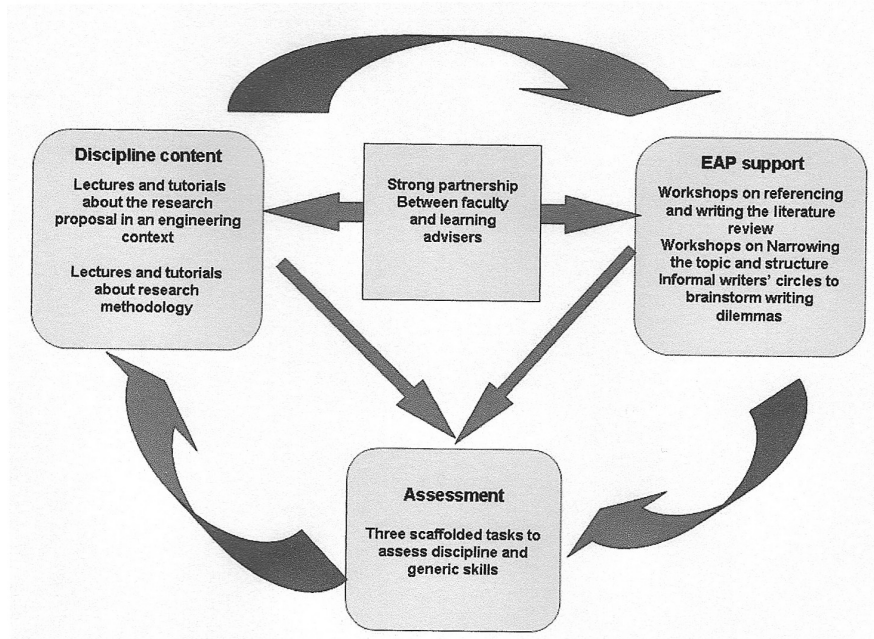


Fig. 2. An holistic pedagogical approach [24].

and Learning Advisers. The table also depicts how these interventions were 'bolstered' from 2005 to 2006.

### 2.3 The collaborative approach

Since research is only tractable when it is clearly defined, all work was aimed to assist students to clearly express their research plans. The interventions in ERP are underpinned by our commitment to foster clear communication. For this reason, both the scaffolding of assessment and EAP approaches were underpinned by a close collaboration between faculty, Learning Advisers and librarians through regular meetings and, importantly, class time for EAP workshops. These were run as 'companions' to the discipline specific workshops about the various engineering research methodologies and included a workshop about referencing, writing the literature review, narrowing the topic and two Writers Circles where students brainstormed their writing dilemmas. In addition students often came individually to seek learning advice.

In both the pre-modification and post-modification presentations of the course we used both engineering and EAP teaching. The amount of teaching effort was very similar in both cases, but the details of activities were different. The assessment effort decreased after the modification because of the reduction in the number of assessment tasks, even allowing for the increased effort of providing more detailed assessment comments. As the assessment tasks became more directed to the actual writing of the research proposal, the EAP effort remained similar (although there was a reduction from five to three Writers' Circles). Interestingly, student confusion about the task

became less and individual appointments with Learning Advisers were less frequent.

### 3. RESULTS

The goal of the ERP developments over two years was to develop the students' abilities to produce a clearly expressed research proposal. The problem with the 2005 approach was that although students performed reasonably well in the preparatory assignments, their lower level of achievement in the capstone assignment indicated that they had not learned what was intended through the earlier assignments. This meant they were inadequately prepared for the final task which was the core competency for which the course was established—to write a goal, methodology and persuasive case for a piece of research.

The restructuring of the course through tighter scaffolding of assessment and the innovations in EAP meant that individual performance in the research proposals improved relative to the preparatory assignments, indicating improved achievement of the principal objectives of the course.

Table 2 shows that both the average mark for the research proposal assignment and the total mark in the 2006 offers of ERP are better than those for the course offers in 2005. Also, the results for the comparison of the research proposal and the average for the preparatory assignments, being *Res\_Prop-Ave\_Prep\_Ass* for both course offers, Semester 1 and Semester 2, in 2006 are positive numbers while the results for both 2005 offers are negative. This result suggests that restructuring the assessment and EAP support, better scaffolded the

Table 2. Assessments Average Results for the four offers of the course\* [24]

	Sem1 2005	Sem2 2005	Sem1 2006	Sem2 2006	All 2005	All 2006
Number of Students	78	61	19	24	139	43
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

\* The marks reported here follow the University of South Australia mark scheme: Pass 2: 50–54%; Pass 1: 55–64%; Credit: 65–74%; Distinction: 75–84%; High Distinction: 85–100%.

learning and prepared the students for their final assessment task. The average marks shown in Table 2 are calculated across the whole class for the particular group of assignments, with the assessment weightings for each assignment, as shown in Table 1. In each case the course coordinator assessed all the assignments, resulting in comparability of the results shown in Table 2. Both semester 1 course were taught by one course coordinator and both semester 2 offers were taught by the other course coordinator. Note that the assessment scale in our University uses a pass mark of 50%.

The outcomes shown in Table 2 indicate the benefit of using the constructive sequence of assessment to promoting student achievement. It may also indicate that the addition of EAP resources, such as the ‘Narrowing the Topic’ and ‘Writing the research proposal’, has impacted on the positive result [24]. These resources were commensurately developed with the refinement of the assessment so independent analysis of the factors is impossible.

Noteworthy is the fact that the average of the results achieved in the preparatory assignments in 2005 was 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. The smaller number of constructive and sequentially designed assessments were more effective in developing student knowledge and skills to prepare a research proposal than and the larger set of assignments that attempted to teach the skills generically.

In addition the constructive arrangement of the assignments forced students to confront the difficult task of developing 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. This indicates that 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 and accompanying EAP support. The two formative assignments in 2006 developed different parts of the research proposal [24].

A more detailed statistical analysis has been done using both the t-test and ANOVA. The result of this study is presented in Table 3.

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,  $F > F_{Critical}$  [24].

#### 4. DISCUSSION

The results of our study clearly point to two key areas to consider in developing discipline-specific communication skills. Firstly, careful consideration needs to be given to the structure of assessment to carefully scaffold and develop the student learning. Secondly—regardless of whether students have English as their first or second language—academic skills need to be explicitly taught—they are not innate. Therefore the results underline the importance of working closely with EAP specialists, library staff and those who provide EAP and academic skills support. This assists students with their learning journeys as they move between cultures—be they undergraduate to postgraduate or country to country—or both.

ERP is, overtly, a course concerning the discipline focused matter of appropriate research methods to be used in engineering, which we know is a new skill for the students enrolling in the course. The articulation of research is particu-

Table 3. Outcomes of statistical analysis of the results [24]

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

larly difficult for those articulating from the non-language rich realm of undergraduate study or from different cultures with English as an Additional Language. For these students, a discussion of the abstractions of what constitutes an appropriate research question is difficult for students to grasp—even if supported with some examples. When we consider the Anglicization of research, the expectation that research is published and expressed in English, attention to EAP is vital [25].

Through careful scholarly reflection on the part of those involved in teaching ERP a reworking of the assessment structure and a focus on communication skills enabled students to better make the connection between *knowledge* of research methodology and the ability to *conceptualise and communicate* this knowledge. In the expression of research, or the proposal for research, it is important for the writer to be able to ‘appeal to the readership’ [26] and put forward a persuasive case. This ability forms a repertoire of ‘generic capabilities’ which directly link to a students’ employability [5]. The importance of this cannot be underestimated when we consider the value employers place on the graduates’ ability to [communicate] *effectively in professional practice and as a member of the community* [27].

It remains the responsibility of engineering educators to ensure their students graduate with marketable communication skills to segue into the engineering field. This is constantly reinforced in engineering education and professional literature [24, 28, 29]. The communication skills must be fostered in a discipline-specific context that balances the ability to convey engineering discourse with the ability to use clear, generic communication skills in order to develop graduates with the ability to clearly communicate the information and conceptualizations which are the content of their professional communication.

The emphasis on embedding the development of generic, as well as discipline specific, skills within the disciplinary context is common in UniSA. While generic skills-based workshops and resources are offered independent of courses, academic staff recognise that the most effective development of discipline based generic skills occurs when these skills are embedded in curricula. This makes the skills more relevant, and directly applicable, than running disparate academic skills workshops which are often tangential or isolated from authentic learning tasks. This embedding, whether provided in a face-to-face or online context, provides support which is appropriate to the student’s particular stage of academic development [17, 19, 30].

Some argue that the development of generic communication skills is contentious [31]. Given that the chief goal of doctoral and masters research degrees is for students to make an original contribution to knowledge, it seems contradictory that at the same time the students should be developing a set of skills common to all of them, and of a kind

which are considered by many as ‘enabling’ professional practice skills. Notwithstanding this, ERP is a masters course which emphasizes the development of discipline contextualised generic skills [15, 26] which goes some way towards redressing the gap in skills faced by those who articulate from maths-rich environments to the language rich aspect of engineering research concerned with the conceptualization and communication of the plan to perform a particular research task.

In ERP, the challenges introduced by this general perspective on the nature of the communication, knowledge and conceptualization nexus are compounded by the fact that many of the students are second language learners and relatively recent arrivals from foreign countries with significantly different teaching, learning and assessment cultures. As a result these students are learning a broad variety of skills simultaneously, without their familiar support structures upon which build.

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. This task is presented in the program as the prerequisite for the Minor Thesis courses, in which the students will perform and report the 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 related 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 specific context of ERP are also generic, work relevant skills, so fostering these generic skills goes some way toward closing the nexus between university study and industry demands of graduates.

## 5. CONCLUSIONS

The approach presented in this paper demonstrates how assessment tasks and the development of generic skills can foster clear communication of a research proposal or idea. This skill maps across to the common engineering practice task of preparation of project proposal documentation which provides students—regardless of their career direction—with a valuable skill. The development of this skill is a small step towards building the professional communication skills required of engineering graduates. The improvement in student results achieved through modified teaching and assessment processes demonstrates the value of scaffolding, EAP support and close collaboration between faculty and language/research specialists. Ultimately this leads to better outcomes for students, building a cultural bridge to understanding the function, communication and language of

the research proposal. Whilst our discussion has recounted the specific case of our research methods course, we believe that this approach is valuable in any course with a final, language-rich, capstone assessment task. Other analogous characteristics include the emphasis on the organization and presentation of ideas. The approach is useful for both native and non-native English speakers.

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