Communication skills developed within the engineering curriculum

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***Abstract**: This paper reports the re-design of assessment criteria and learning activities so that the development of communication skills is integrated into the engineering curriculum. This re-design was specifically for the benefit of engineering students, and resulted from a partnership between engineering academics and literacy teachers. It has been informed by measures of student performance (primarily), staff observations about student engagement, and student feedback about engagement. Engineering students can be both emotionally and intellectually engaged in a positive way when completing tasks of a written or spoken nature. This engagement is generally true even for struggling and reluctant students. Improvements have been observed in students' organisation of information, understanding of the respective purposes of different texts, compliance with grammatical rules, use of English expression, reflection on their own abilities, and pursuit of further improvements to their communication skills.*

Introduction

This paper reports the design of assessment and learning activities that have been integrated into the engineering curriculum and which have been engineered specifically with engineering students in mind. Many undergraduate engineering students are poor readers, writers and presenters. Others are simply reluctant to engage with these skills. Traditional courses developing academic literacy or communication skills are rarely designed for engineering students and are, thereby, generally less effective, due to both a perceived lack of relevance and tasks being incompatible with the preferred learning style of most engineering students. We have taken a less conventional approach, and modified the existing engineering learning activities for purposes of developing communication skills, rather than use pre-existing communication exercises.

Almost all students entering a BE program are unfamiliar with the communication forms expected within the engineering profession. Given this ignorance, then, how and when will they be able to learn them? In the traditional structure of most courses, it is implicit that students will acquire such skills intuitively and, hence, there is no provision of explicit instruction and guidance. For example, in 1998, the only instruction provided in one of the Stage 1 engineering courses was "write a report, 1200 words." It was not surprising that most of the assignments submitted were of a poor standard. To assess students on matter which is not explicitly taught or practiced in a course is unethical.

It is recognised (e.g., Brent & Felder 1992) that the study of generic professional skills, such as appropriate writing and speaking, should be integrated into the curriculum, thereby enabling them to be learnt in the context of the relevant disciple. This means that students better see the relevance and contribution these skills make to their professional competence. Indeed, a formal survey of our own Stage 1 students revealed that they actually expected to learn such skills within their BE courses. As a range of assessable tasks exist in the BE program and all require some form of communication, integrating relevant instruction about communication skills, and supporting resources, should be straightforward: adapt existing, standard learning activities to include timely instruction about the

appropriate communication forms, provide explicit assessment criteria so students recognise its importance, and give supplementary support.

Although straightforward, it is not always easy. The expertise to improve communication skills is not ordinarily possessed by an engineering lecturer, so there is an immediate need for external consultants, notably the literacy teachers of an institution. As with all such professional co-operation, developing this relationship takes time before the benefits are seen. The jargon and cultural traditions of most literacy specialists differ from those of the engineering discipline. Of course, some teaching staff are not as keen to co-operate as others are. Patience is the only response. If suitable assessment tasks cannot be identified within a BE syllabus, then communication skills cannot be developed within that particular programme of study, and a deeper structural problem exists in meeting professional expectations.

In the next Section we discuss some of our examples of adapting pre-existing tasks and integrating the development of communication skills into the curriculum; following that, we present evidence that these improvements actually work; and, finally, we provide indicative student responses showing their support for the approach. Readers are invited to contact the authors to discuss these and further example activities and resources in more detail.

Examples of learning activities

This section describes some learning activities which have been integrated into undergraduate courses in the UNSW BE program. These activities exemplify the redesign and support of standard BE assessment tasks with the view to improving engineering students' communication skills. As the learning activities build on what students are required to do, they are perceived to be relevant and, hence, are better accepted by both teaching staff and students.

In the Stage 1 design course, students must write a sequence of reflections to show what they have learnt about the design process. In 2006, the first such task was adapted for use as a tool to diagnose each student's level of academic literacy, exploiting the MASUS methodology (Bonanno & Jones 1997). Students received feedback on their ability to answer questions, locate and interpret information, and communicate this clearly in writing. Those identified as being weak communicators could then take an elective course specifically designed to develop engineering students' communication skills. A detailed description of this approach is found in Skinner & Mort (2009).

It is common for new students to be assigned a research task which requires a short, informative report. This is an authentic task, reflecting the professional providing an overview of a technology and giving recommendations to a client. Such a task is designed to develop students' information literacy, introduce students to features and conventions typical of technical reports, and develop students' writing skills. Including one or two hours of lectures on report-writing is a logical and worthwhile change to the class schedule. These lectures are easily supplemented with 'texts' on report writing, made available as hard or soft copy to the students. A similar approach has been used for Stage 1 and Stage 2 design proposals and design reports. Each of these is a distinct writing type within the engineering conventions and must be introduced to students.

Another authentic task is the literature review, which is required of Stage 4 students in the first half of their thesis projects. For the majority of these students, this writing is their first attempt at a literature review. Workshops (from 2 to 4 hours with 40 to 90 students participating) and print-based resources have been embedded in a number of engineering schools with lecturers reporting a positive response by most students. Authentic examples of previous, good Stage 4 literature reviews are used to show students how to structure the literature review, what language features are typical in a literature review, and what conventions are required for the BE thesis.

A website on thesis writing in science and engineering functions to supplement lectures and workshops by offering further examples and exercises for students to access at their own convenience. Learning activities include: FAQs based on common student questions and answered by faculty staff; descriptions of examiner expectations, common problems, and examiner advice/solutions; annotated extracts from good theses; and short quizzes and exercises (Learning Centre 2005).

An extensive online learning environment has been developed in collaboration with the University of Sydney (Universities of Sydney & New South Wales (2009). This resource includes a module on writing field-trip reports. This module was integrated into a Stage 2 mining engineering course, by using two short lecture-based demonstrations (each 15 minutes) and timely email reminders about how to use the module.

Other authentic tasks require spoken communication skills. One assessment task requires students, in teams of 3, to interview a member of the academic staff in order to prepare a short report on the daily life of an academic and to make recommendations about challenges identified by the interview. Lecturers are willing and flattered to be interviewed. Learning outcomes include the development of group communication and planning skills, awareness of the varied activities of an academic engineer, and an understanding of basic report structure and formatting. Learning activities include group work on preparing and critiquing potential interview questions, reflection on strategies and behaviours to ensure a successful interview, and peer review of draft reports. Many students have little direct contact with lecturers, particularly with large classes, and the opportunity to research an engineering 'academic' is something students look forward to.

For some time, traditional oral presentations have been used as a learning activity to develop oral communication skills. However, a lack of engagement by both presenters and audience means that the end result is unsatisfactory for all parties, including the teacher. Many engineering students enjoy a competitive edge in their learning activities and have shown better engagement in classroom tasks which have an authentic and competitive framework. An oral communication task that is both competitive and authentic is the debate. Engineers need to defend a point of view, be aware of and take into account alternate views, and refute counter arguments with evidence and reasoning. The debate is a challenging learning activity requiring teamwork, research skills, high-level critical analysis, and the ability to think 'on the run'. Learning activities include practice debates to learn the rules and processes, using pre-prepared notes to learn strategies and plan their arguments, guided research in computer labs to develop information literacy skills, and debate planning templates for each speaker. When compared to the traditional oral presentation, we can confirm that the presenters and the audience are much more engaged.

Some resources have been adopted first as a 'school standard' for presentations and then for use in assessing students' reports. Sample school writing and speaking guides can be viewed on-line (e.g., Learning Centre 2009).

Evidence of effectiveness

It is all very well to have learning activities and resources, but they need to be effective. We have systematically and ruthlessly discarded activities unless they led unambiguously to improvements in student achievement. We are now confident of those we use. Here is some of the evidence that persuaded us.

Diagnostic measurements: Since the development of the diagnostic tool for use with Stage 1 students, it has become relatively easy to identify changes to an individual student's communication skills (academic literacy). In Figure 1 you can see the changes to the scores of the Stage 1 students who completed the formal elective course and both the before- and after-diagnostic tests. For each of students A to H, there is a shift on a 4-point scale, for each of the four indicated aspects of their respective academic literacy. The major improvement in grammar is of special interest, as it not the primary focus in that course, but consistent with what we have observed in other courses about the ability of engineering students to learn formal grammar, when given the opportunity.

Report writing: Feedback from lecturers is unstructured and anecdotal. Nevertheless, it is useful, and, by now, has become very positive in tone. For example, since the lectures on report writing were introduced, staff consistently report that most Stage 1 students can now produce a document that looks and reads like a report; one lecturer even noted that the Stage 1 students can write better reports than can some PhD students. Lecturers have also commented that, once students are better able to structure and present their written and oral communication, it becomes more obvious to markers where there are

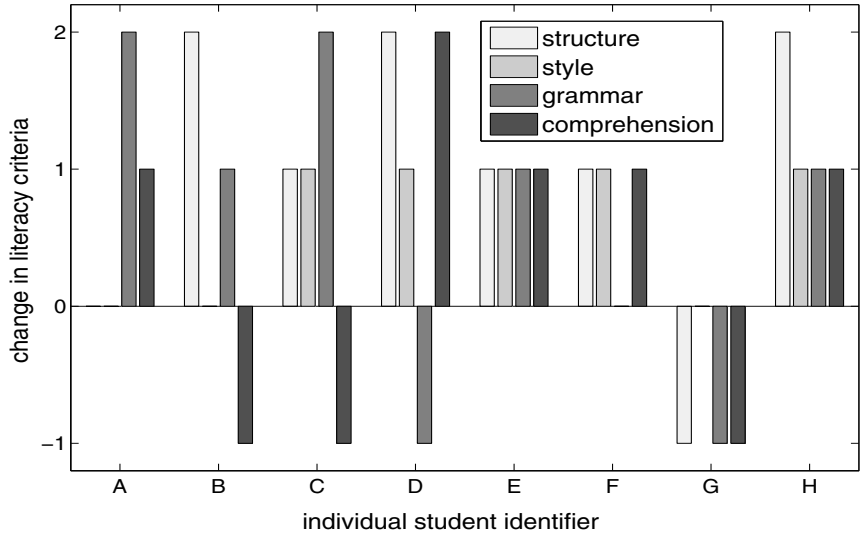

Figure 1: Differences between final and initial literacy test (2007 class).

gaps in content and understanding. This is valuable feedback to the lecturer about how well students are achieving the learning outcomes of the task, but it also permits marking to be more rigorous.

Theses: The longer-term impacts of the students' experience of learning activities that improve their communication skills, and particularly the structure of written documentation, is seen in the final year theses. There are several examples of students who were identified as being at-risk upon completing the Stage 1 diagnostic, but who undertook specific supplementary learning and whose theses passed because of the excellence of the structure and format. Markers could find the relevant information because it was in the right place and correctly presented.

Online resource feedback: Lecturers have reported that, although students appreciate face-to-face instruction, they also refer to printed and online resources during the semester, e.g., while preparing a literature review or thesis report. An online resource supporting the writing of the final year thesis was launched in 2008. Records of page requests confirm this observation: there is a sharp rise whenever a major assessment falls due, as shown by the asterisks in Table 1. Page-hits exceed the number of students, confirming that the resource is useful enough to re-visit. The workshops were provided early in session and the review was due mid-June.

Table 1: Thesis writing website page-requests

Month	2008	2009
January	162	2037
February	388	2232
March	273	3108*
April	259	2716
May	936	3639*
June	1876	2695*

A cross-institutional online learning resource (WRiSE) was launched in 2009 and tested with Stage 2 BE students at UNSW. Markers reported that students showed improved organization of sections and information in their field-trip reports, improved introductions and conclusions, and a much improved and concise writing style, overall, when compared to previous years. Attention to details in formatting and referencing is an area that many could still improve. From 2010 computer-based workshops will be used to explain better how to use the resource.

Examples of Student responses

This section briefly provides some representative reactions of students to our modifications of the traditional BE assessment activities and criteria.

Official course surveys: Within the formal elective course, the official student survey instruments provide the desired quality assurance. Students agree that that the activities are suitable for and effective in improving their academic literacy. Specifically, over 85% of students in each of the 2007, 2008 and 2009 classes agreed that the learning activities both supported the course's objectives and were relevant to the engineering context. They do not necessarily enjoy all actvities, of course, but by now we have dispensed with any very unpopular ones. By the end of the course, students even appreciate their teamwork activities, although they find them daunting at the beginning, when they know no-one else in the class.

Other class surveys & focus groups: It is interesting to note that, when explicitly asked in 2003, 69 out of 115 (63 %) Stage 1 students reported that they liked the lectures on report writing. Indeed, this was a higher rate of appreciation than that earned by most technical topics, typically 40 to 50 %. Students were asked in 2008 for open-ended feedback about the Stage 4 Mining Engineering workshops on writing a literature review. Of 11 students who replied, 6 reported that use of annotated examples is most helpful, and requested more of these to highlight the structural and language features typical both in a literature review and also the thesis more generally. As an example, consider

> *''Definitely needed an appropriate example, … to do with mining. This would have been very helpful in changing a student's perspective on writing.''*

Annotations and terminology are informative and easy to learn, providing students and staff with a common language in which to talk about texts. Print-based resources have been updated with additional examples (2009 edition) and future additions to the online resource are planned.

Other: Apart from the formal feedback, there is much student evaluation that is anecdotal and informal. Nevertheless, it is valuable and informative. One of the more unexpected, yet consistently recorded, sentiments concerns their realization of just how much effort is required to develop good communication skills, although they concede that it is worth doing so! For example,

> *''This course was much more work than any other [equivalent elective], but it was worth it.''*

Finally, it is noteworthy that while peer feedback is useful to the students' learning, they do struggle with both providing it and receiving it. There is an attitude that this is rightfully the teacher's responsibility and privilege. A reviewer reminded us of the Engineers Australia competencies that include the ''ability to mentor others, and accept mentoring from others, in technical and team issues'' (PE3.5(e), Engineers Australia 2006).

A happy ending: Ultimately it is up to students to improve their communication skills. Some students do realise their strengths and weakness and make a conscious effort to improve. In 2007 a Stage 1 BE student, who had been diagnosed to be 'at-risk,' responded positively and enrolled in the elective designed to develop understanding and skills in communicating in engineering and science. He successfully completed this course and, although showing high motivation to improve, he still needed to work on his communication skills. He selected more courses with learning activities that could further develop his communication skills and finally participated in UNSW's 'research scholars' summer program. His poster was short-listed as an example of a good poster. This student has made great progress by taking advantage of opportunities in the engineering program which can extend and improve a students' learning and communication skills.

Lessons learnt

The development of integrated communication skills development has been a process of continual improvement and has been driven solely by meeting the needs of students. Students have responded constructively to all requests for feedback on the integration of learning activities about communication skills with their engineering courses and the provision of supporting resources. To this end we are continually adapting and improving many aspects of delivery, content, supplemental resources and timing of learning activities, using the existing syllabus and learning activities as a

basis. This ensures the activities are helpful, engaging and relevant. This relevance is not only seen by students, but also the cautious lecturers.

In general, engineering students can be emotionally and intellectually engaged in completing structured and assessed learning activities. They simply need to be well designed. Tasks that improve their written or spoken communication skills are no different. Positive engagement is generally shown by both weaker and reluctant students, as much as by good ones. Students are more engaged with activities that include any or all of the following features: (i) relevance to an engineering context (subject matter) and practice (authentic); (ii) visual elements instead of textually 'heavy' ones; (iii) teamwork and competition; (iv) kinesthetic or physically active components; (v) use of real examples for comparison and critique; (vi) a challenge, but with supporting 'procedures' should things get too tough; (vii) formative assessment, including peer feedback; (viii) feedback, which is detailed and constructive; and (ix) clear specifications for all tasks, including their respective purposes and relevance to engineering practice.

Two benefits follow from adapting assessment tasks already in the students' courses of study. First, the students have an immediately identified professional context that provides better motivation than traditional, stand-alone communication tasks, too often anchored in the humanities. Second, the teaching staff does not resent them. Too often, communication activities have been inserted into a course and then viewed with suspicion because of a perceived compromise to the integrity of the engineering syllabus.

These adapted activities have produced improvements in how students (i) organise information, (ii) understand the respective purposes of texts and adapt information to them, (iii) use grammar and English expression, (iv) examine their own strengths and weaknesses, and (v) pursue further improvements to their communication skills.

In conclusion, we stress that it is possible to develop communication skills by integrating learning activities and resources with traditional engineering assessment tasks. All it takes is collaboration, imagination, flexibility and patience. The students will appreciate the effort. You might even enjoy it, too.

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