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Writing: An Essential and Powerful Communication Tool for Today's 'Three Dimensional' Engineering Graduate

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Abstract

Today's engineers are expected to be versatile, necessitating a bold shift in the direction of Australian undergraduate engineering education. Alongside the capacity for technical analysis, core engineering graduate attributes emphasise non-technical skills: (i) the ability to communicate effectively, (ii) the ability to function as reflective practitioners on multidisciplinary teams, and (iii) the broad education necessary to understand the impact of engineering solutions within a global, economic, and environmental context. Increasingly, students are coming from a diversity of backgrounds – academic, cultural, and professional – and academics are being required to meet the complex professional demands they bring. Recognition of the need for literacy support where cohorts comprise a high percentage of students from a non-English-speaking background with strong science/math competence, yet little experience of writing academic English, is challenging. Effective literacy support requires early identification of problems in large undergraduate cohorts. Evidence demonstrates that literacy support is most effective when closely integrated with core assignments and relevant to dynamic professional practice.

Introduction

This paper addresses the theme of the roles of writing development in higher education and beyond, with an emphasis on developing and sustaining writing practices in and across the disciplines, focusing specifically on the discipline of engineering and on ways in which writing development can impact beyond higher education in preparing students for writing in the professions. For over twenty years, discussion about students' literacy levels has been rife in Australia's tertiary engineering context and there has been continued concern about communication skills, but there has been little advance (Wulf and Fisher 2002, Tenopir and King 2004 and Dym *et al.* 2005). This paper reports on an ongoing collaborative endeavour between the Learning Centre and the Faculty of Engineering at the University of Sydney that assists in meeting this changing need. The current language support program is the result of over five years of close liaison, rapport, negotiation and willingness between faculty and Learning Centre academics, towards a mutual recognition of each others' fields of expertise that develops a positive attitude towards writing as an essential and powerful communicative tool for engineers.

The Australian Context

It is predicted that an additional 20,000 professional engineers will be needed to meet current demand in Australia in the near future (Carrick Grants Program Report 2008). Today's engineers are expected to be versatile, ethical, social agents. These requirements necessitate a bold shift in the direction of Australian undergraduate engineering education. Alongside the capacity for technical analysis, core engineering graduate attributes emphasise non-technical skills: (i) the ability to communicate effectively, (ii) the ability to function as reflective practitioners on multidisciplinary teams, and (iii) the

broad education necessary to understand the impact of engineering solutions within a global, economic, and environmental context.

Theoretical Context

Theoretical principles that have guided the University of Sydney's language support program's practice draw on a wealth of research over the past twenty years from Writing Across the Curriculum (WAC) and Writing in the Disciplines (WiD) (Hyland 2008, Hyland 2009, Hyland and Tse 2007, Lea and Street 1998 and Dym *et al.* 2005).

Key challenges addressed in designing appropriate language support include:

1. a mismatch between what is currently on offer in engineering degree programs (in Australia) and qualities/characteristics desired by prospective employers;

2. engineering students' perceptions of writing as 'peripheral', and 'learnt outside "real" engineering';

3. engineering degree programs' emphasis on problem solving and mathematical skills, thereby implicitly placing higher value on the practical, applied dimension of the engineering graduate, and simultaneously neglecting the social, interpersonal dimension.

The Classic Engineering Stereotype

Many are familiar with the classic engineering stereotype as 'the type of person who would rather take the telephone apart than call his own mother' (Clayton 2004), or the 'nerd'/'techie' who cannot communicate. Knapp (1984: 3) portrays this stereotype in a cartoon of two women talking and the punchline, 'My son never writes home—he's an engineer'. Wulf and Fisher (2002: 2) state that a clear preference is expressed by industry for the three-dimensional graduate who is technical, personal, and professional as opposed to the 'traditional stereotype of the asocial [two-dimensional] geek'. Core technical knowledge is fundamental for engineers, and a focus on practical issues such as cost and safety are clearly important, but such issues should be framed within a broader social context. An engineer's close attention to specific detail can cause him or her to overlook the broader relevance (as reflected in engineering students' responses to the MASUS diagnostic task on which this paper will report). Current engineering curricula tend to reinforce these emphases.

Beyond Higher Education

There is a need to address the complexity of the contemporary professional engineering environment and the employer demands of a global community of professional engineers, where some practicing engineers say they spend up to 80% of their time in oral and written communications (Clampitt 2005 and Dowling, Carew and Hadgraft 2010). There are serious concerns that the balance of subjects within current engineering curricula are not adequately matched to stakeholders' current and future needs, and employers have also raised concerns of poor standards of report writing (King 2008: 7). In summary, there exists a wealth of evidence (Dowling, Carew and Hadgraft 2010, King 2008, Trevelyan 2007, and Wulf and Fisher 2002) that argues that employers want engineering graduates who are, above all, versatile. The following '7 Cs' are frequently cited:

1. Common-sense,

2. Creativity,

3. Communication,

4. Collaboration (teamwork),

5. Commitment (project management),

6. Command (leadership),

7. Caring (inter-personal skills).

The ability to communicate effectively is seen as crucial. The following scenarios, for example, show how communications procedures between professional engineers and management have failed, leading to serious economic and tragic consequences:

1. *The Challenger disaster*, January 28, 1986, where failure of the spacecraft was due to the faulty design and lack of testing (technical skills) coupled with a lack of communication between engineers and management, resulting in seven astronaut fatalities (Greene 1996);

2. *The product recall of the Toyota Prius,* 2009, where more than 400,000 hybrid cars were recalled worldwide due to safety issues, but the crisis was compounded by management issues (failure to communicate and act quickly) and contributed to the ensuing damage to Toyota's reputation worldwide (Blackburn 2010).

Behind the scenes of these disasters were many important lessons about organizational dynamics and communication. These real-life scenarios demonstrate that while technical competence is an essential attribute for engineering graduates, it alone is insufficient. The following extract from a course text for the Flexible First Year Engineering Program at the University of Sydney aligns with the demand for the new breed of engineer, reflecting the complex, multidisciplinary context of the contemporary engineering workplace:

> The modern professional engineer needs a more complete set of skills than any other profession. In addition to excellent technical skills, they must be economically, environmentally and politically literate, work effectively as a leader and a team member, manage projects and people, and communicate all this clearly to colleagues, clients, governments and the community (Johnston 2006).

According to Goldsmith *et al.* (2009), findings from a regional forum, as part of an Australian Learning and Teaching Council (ALTC) funded project, '*Design based curriculum reform within engineering education*', reveal that today's graduate is likely to advance quickly into a management role. As managers, engineers are required to communicate persuasively in a global context of increased e-mail and web usage. Daily interactions typically involve encouraging peers, taking on ethical responsibilities, coordinating, consulting, leading meetings, influencing people, supervising (technicians), managing conflict and directing peer interaction using a range of media such as emails, reports, drawings, and the Internet (Trevelyan 2007).

The Engineering Curriculum

Given the common perception of the engineering graduate in marked contrast to preferences expressed by industry, it is evident that the current curriculum has contributed to this unacceptable position. Crucially, we must ask, how can we, as curriculum developers, address these shortcomings and engage in appropriate curriculum reform to resolve this mismatch? A typical engineering curriculum emphasises 'hard' courses: the technical, mathematical, computational and problem-solving nature of engineering. Often missing is any emphasis on the value of 'soft' skills, that is, the non-technical, or social aspects such as communication and interpersonal skills (Johnston 2006 and Trevelyan 2009).

Students should be given appropriate, authentic learning activities, in the comparatively less-competitive and less-pressured environment of the university, in order to develop relevant communication skills that will enable them to perform in the above roles as successful mediators involved in interactions with professionals from a diversity of disciplines, e.g. business and

economics, architecture, and design. Communication skills are essential for the transfer of relevant experience to less-experienced others.

The following section reports on the value of writing as a key communicative competence and how it has been successfully integrated into a first-year core Unit of Study in a three-year Bachelor of Engineering degree program at the University of Sydney.

Learning Centre Intervention in First Year Engineering

Embedding communication skills into core, credit-bearing Units of Study in engineering degree programs at the University of Sydney has not been without challenge and there was initial reluctance among some students and discipline academics. Initial attempts between the Learning Centre and the Faculty of Engineering at the University of Sydney in 2004, offering optional attendance at adjunct seminars focusing on language support, did not prove very successful. Further discussions with faculty academics and language specialists in 2006–2007 resulted in a more curriculum-integrated approach to language support and early diagnostic assessment of literacy skills. This initiative was implemented in 2007 and is subject to continual revision following student feedback and program changes. Challenges and changes in the professional workplace continue to drive the shift in curricular design and current course texts reflect ways in which employer and workplace demands are subtly influencing the curriculum.

Professional Engineering (ENGG1803) is a first year core Unit of Study in a Bachelor of Engineering program within the Faculty of Engineering at the University of Sydney. It seeks to acquaint newly-admitted undergraduates with the principles of professional engineering practice and a range of contemporary professional engineering issues, together with the skills of academic study within an engineering environment. The subject is structured around a design and build project, in which students apply the professional engineering they are learning to an engineering design project. Professional engineering topics covered include: accessing information, teamwork, creativity, leadership, written and oral communication, project management, problem solving, ethics, liability, occupational health and safety, and environmental issues.

Cohort Profile

Undergraduate engineering student cohorts enrolled in the Flexible First Year Program *Professional Engineering* at the University of Sydney typically comprise approximately 340 students. Increasingly, students are coming from a diversity of backgrounds – academic, cultural and professional. Recognition of the need for literacy support where cohorts comprise a high percentage of students from a non-English-speaking background with strong science and math competence, yet little experience of writing academic English, is challenging.

Methodology

All students in this core Unit of Study are required to complete a writing diagnostic, Measuring Academic Skills of University Students (MASUS), in order to proceed. The MASUS diagnostic tool, developed by Bonanno and Jones at the University of Sydney in the early 1990s, has since been adapted and applied to a range of undergraduate and postgraduate cohorts (Bonanno and Jones 2007). The procedure identifies students who are at risk of failing a course because of poor literacy skills, thus guiding and enabling effective language and literacy support. The MASUS diagnostic procedure has been designed to assess the ways in which students process knowledge and how they respond to a specific question, looking at skills involving analysis and evaluation of information, argumentation, and discussion. A possible 16 marks are available. Those students attaining less than 9/16 are assigned to the Communication Cohort for integrated language support.

Table 1: Measuring Academic Skills of Undergraduate Students (MASUS) Diagnostic Criteria (Adapted for 'Professional Engineering' Program at the University of Sydney**,** 2010)

Aspect of writing	**Criteria**	**Rating 1–4**
1. Information retrieval and processing	• appropriate selection of information • information transferred correctly • source material integrated into writing • writing free from plagiarism	
2. Structure and development of the text	• correct question answered as required • writing properly organised in paragraphs • logical argument developed • evidence well used to support argument	
3. Use of appropriate academic English	• appropriate style employed in writing • choice of vocabulary appropriate	
4. Grammatical correctness	• grammar free from obvious errors • sentences well structured	

The MASUS diagnostic is implemented in week one or two so that literacy problems can be identified early and language support put in place accordingly. Input for the writing diagnostic task is selected as a result of the combined expertise of discipline specialists within the Faculty of Engineering and the Learning Centre academics with their expertise in language, and reflects current concerns in professional engineering. In 2010 the topic for investigation was Toyota's product recall of the *Prius* and the ensuing damage to Toyota's reputation. Students were required to respond to the question as an engineer newly appointed to the Research and Development Division in the form of a short persuasive essay (800 words).

MASUS feedback

The following comments illustrate general characteristics of the written responses:

- a significant portion of students explained how the specific problems (wooden brakes, sticky pedal etc.) could have been avoided, rather than making forward-looking recommendations,
- failure to write a 'flowing' piece – instead [five] discrete sections,
- a lack of introduction and conclusion,
- overly personal language e.g. '*I believe* that Toyota...' / '*In my opinion* Toyota...',
- issues with basic capitalization, e.g. lots of '*toyota*', '*lexus*' and '*prius*',
- many students focused only on specific issues, e.g., faulty brakes, demonstrating a failure to generalise from the various problems mentioned in the texts to identify more abstract key issues. For example, students wrote: 'the managers didn't react fast enough', instead of, 'a need to review management culture/procedure etc.'; or they wrote 'sticky pedal', 'slippery mats' and 'wooden feeling brake' as three discrete key issues rather than synthesizing these into recommendations: e.g. 'a need to review quality assurance protocol'.

In general, students neglected to address the bigger picture in terms of broader global issues, namely, the damage caused to Toyota's reputation, management communication problems and actions necessary to control the damage. As a result of their performance in the writing diagnostic, students are placed into three ability groups, respectively, *Engineers Without Borders, Main Cohort* and the *Communication Cohort*, hitherto referred to as CC. The CC group participates in 13–15 hours of an integrated literacy support program delivered throughout semester from weeks 5–11.

Communication Cohort (CC) profile

The CC typically comprises a high percentage of international students (95% from 2007–2009), whose first language not English. From 2007–2009 the CC group size varied between 32 and 38. In 2009 (Semester 2), 32 students were identified who would benefit from support. Results from the MASUS diagnostic enable early identification of areas of language difficulty and the implementation of appropriate literacy support. Forms of integrated literacy support currently being offered are not restricted to writing (see Table 2). All forms of support show close alignment to assessment tasks grounded in real world, professional scenarios.

Table 2: Integrated Language support: Links to Assessment Tasks

Week	Tuesday	Assessments	Thursday
1/2		MASUS diagnostic	
3	**Overview-** ❖ **Non/technical skills development** ❖ **MASUS feedback** ❖ **Attitudes to writing** ❖ **Time Management Handout** ❖ **Grammar: Sentence**		**Writing an essay** **Description/analysis/ argument** **Paragraph** ❖ **Topic sentence & paragraph development** ❖ **Cohesion** **Evidence: paraphrasing & summarising**
4	**Reading strategies**	Essay	**Referencing and plagiarism**
5			**Presentation skills:** ❖ **Spoken vs written language (cline)** ❖ **Structure of talk/paper** ❖ **Performance attributes** **Presentation skills practice (feedback)**
	Mid-Semester Break		
6	**Project presentation**	Presentation	**Project presentation** **Report Writing:** ❖ **macro level / paragraph level** ❖ **structure, style and language**
10		Draft report	
11	**Feedback on draft report**		**Preparation for final report**
12			
13		Report	

Discussion and Findings

The integrated literacy support program offered to these students comprised two hours of lectures, ten hours of tutorial support and two hours of observation of student presentations, in which Learning Centre academics and discipline tutors were involved in coordinating group activities and providing timely feedback to students on their assessment tasks, in both oral and written modes. The written

communication skills component covered reading strategies, language work, with an emphasis on analysis and argumentation, referencing, plagiarism and using evidence, and covered key aspects of formal report writing. Important features of structure, language style and layout were explained and modelled. The spoken communication skills component of the course covered spoken versus written language, structure of a talk and performance attributes. It also provided a valuable opportunity for practice and feedback of a brief presentation.

Overall, the impact of the program has been positive. Initial reluctance from faculty, and to a lesser extent from the student body, has shifted markedly to a clear realisation of the value of focusing on non-technical skills which are reflected in the improved results of the CC. In terms of student performance, the CC group showed improved results relative to some students in the main cohort who did not have access to the integrated language support. Below is a summary of student evaluations of the language support program offered to the CC group. Students were asked to indicate the extent to which they agree or disagree with five statements using a five point scale ranging from [1] = strongly disagree to [5] = strongly agree:

- I have learned valuable skills in this workshop (78% agree)
- The teaching in this workshop helped me to learn effectively (89% agree)
- The workshop materials helped me to learn effectively (73% agree)
- I can see the relevance of this workshop to my degree studies (89% agree)
- Overall I was satisfied with the quality of this workshop (83% agree)

Program findings, therefore, show that in a core Unit of Study, top-down valuing of learning and teaching practices gives a program stability and institutional value. Close liaison, rapport, negotiation and willingness between Faculty and Learning Centre academics, towards a mutual recognition of each others' fields of expertise, develops a positive attitude towards writing as an essential and powerful communicative tool. The naming of the cohort also influences students' attitudes to the success of the intervention program and it is important to avoid any possible associations with remedial practice or separation from other cohorts that imply negative connotations. Embedding highly relevant writing assignments into disciplinary knowledge is central and pertinent to the success of effective intervention programs.

Practices such as team teaching, which combine both the expertise of discipline academics and language specialists with recent graduates of engineering who can draw on recent professional field experience, are invaluable, highly recommended and mutually beneficial. Students immediately feel that there is an authentic link between their current learning experiences and their prospective professional practice. Similarly, recent graduates have the opportunity to share professional experiences and directly contribute to relevant learning experiences in the academe. These practices enrich and sustain essential links between the tertiary sector and industry. Practice confirms that intervention should be firmly grounded and contextualized in authentic intellectual activity in order to develop a positive attitude towards writing as an essential and powerful communicative tool. Curricular reforms that foster the integration of the development of communication skills into disciplinary knowledge (both written and oral modes), as an authentic aspect of professional engineering, not only help to cultivate these essential professional competences, but also help to dispel the stereotype of engineers as poor communicators.

Conclusion

It is overwhelmingly clear that today's engineers need to be able to perform as effective communicators capable of using a variety of modes of inquiry – oral, visual and written – as engineering becomes increasingly complex and multidisciplinary (King 2008). This paper has argued that the workshop intervention can be strategic in integrating writing as a powerful communication tool into the curriculum as integral to disciplinary knowledge. It has focused on the diagnostics involved in

isolating and designing the necessary interventions for the new student body profile. Key ingredients that contribute towards success in the immediate term include ensuring that:

- the cohort does not feel 'special' (i.e. remedial). This would be counterproductive to progress, rapport and willingness to participate;
- assignments parallel main cohort tasks;
- team teaching is provided by faculty academics (content specialists) and language experts;
- faculty understand and are committed to the value of integrated literacy support for non-technical skills in a core Unit of Study.

The value of such interventionist programs must be considered in the long term, through the degree program and beyond higher education into the workplace. For the future success of similar interventionist support programs it is imperative that this early focus on communication skills (integrated into first-year core Units of Study) is developed across the degree program through the second to fourth years. While this conversation has been rife for over at least two decades, we must not lose sight that while change may not be occurring as fast as some would hope, nevertheless, there are a significant number of informed, concerned, willing and enthusiastic participants in the tertiary sector to fuel an optimism in reaching the desired objective.

Future challenges

Engineering faculty, Learning Centre staff, and university managers need to affirm that these changes are incremental and retain a pragmatic and realistic worldview that we are participants in a marathon, rather than a sprint, which requires concerted effort over a period of time. Such an endeavour requires ongoing and embedded executive-level understanding and commitment, plus dedicated funding; a commitment to working with attitudinal change over the long term; leading by example; and rising to the challenge of building an integrated presence in the faculty and across the curriculum over time. The importance of forging strong partnerships with individuals and organisations internal and external to the university cannot be overestimated.

The knowledge gap that prompted this contribution reflects a trend in the engineering professions that suggests a high future demand for engineering skills at all levels. In order to meet this demand from within the tertiary context, close collaboration of discipline academics and language specialists is required to prepare students for writing in these highly competitive professions. In this way, language support will emerge in accord with the changing professional needs of all stakeholders: students, academe and, not least, prospective employers. In the collaborative Engineering Faculty/Learning Centre intervention program at the University of Sydney, we have sought to address some of these challenges.

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