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Disciplinary specific communication and literacy for engineering students

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ABSTRACT

CONTEXT

Western Sydney University, The College provides pathway programs into Western Sydney University (WSU). Graduates of The College can transition to their first or second year of a Bachelor degree at WSU. Part of the Diploma of Engineering at The College is the completion of a 12-week professional communication and English literacy subject, *Professional Communication Skills for Engineering*. The subject was originally delivered as a generic English subject, however, it has recently been redesigned through the use of to reflect specific communication nuances of the engineering profession.

PURPOSE OR GOAL

The ability to communicate effectively in English is an important skill for professional engineers. Furthermore, the improvement of literacy through the use of authentic content is a key element of transition pedagogy (O'Donnell et al., 2015; Kift et al., 2010). Accordingly, the aim of this project was to establish the effectiveness of a customised English communication subject for the Diploma in Engineering.

APPROACH OR METHODOLOGY/METHODS

The assessments and themes of the English literacy subjects previously completed by engineering students were reviewed and redesigned to closer reflect their academic and professional needs. The communication genres used within the industry were included for both learning materials and assessments. The effectiveness of this approach was measured by a longitudinal study of trends in student feedback and pass rates.

ACTUAL OR ANTICIPATED OUTCOMES

This approach resulted in a significant increase in student pass rates indicating a engagement in the subject compared to its generic equivalent. The reasons for these improved results may be the explicit relevance of the subject to engineering students.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

In conclusion, the most significant finding of this study was that delivery of this discipline-specific English subject to engineering students resulted in improved student performance and led to higher average pass rates than its generic equivalent.

KEYWORDS

Transition, Retention, Literacy, Communication, Engineering

Context

On 28 January 1988, the Space Shuttle Challenger lifted off from Cape Canaveral in Florida. Less than two minutes into the flight, it broke apart killing all seven astronauts and halting the US space program for nearly three years. Despite warnings from the engineering team pointing at potential technical issues, the launch was given the go-ahead by NASA resulting in a tragic disaster. This oft-cited tragedy is an example of poor communication that led to the failure of a promising project and the loss of lives. Had there been effective communication and debate between the engineering design team and the launch controllers, had the arguments and fears put forward by the engineers been taken into consideration, the disaster could have been prevented. Wilson-Lopez & Minichiello (2017) offer this example to "underscore the criticality of literacy in engineering" (p. 7).

Engineering professionals undertake a multitude of tasks, some of which are common among the various engineering streams, and some of which differ depending on the branch of engineering and the scale of projects.

Engineering professionals design, analyse, evaluate, test, build or invent new solutions. This often involves interpreting information using a multitude of professional texts such as codes and regulations or graphical data to identify and define problems, and ultimately resolve them. Additionally, engineers produce an array of texts that result from interpreting content, gathering evidence, constructing arguments, evaluating, recommending, justifying (Wilson-Lopez & Minichiello, 2017), and tracking how solutions meet prioritised sets of criteria and constraints (Dym et al., as cited in Wilson-Lopez & Minichiello, 2017). Thus, a combination of hard and soft skills is required to ensure successful professional outcomes. Indeed, according to Riemer (2002), "knowledge and technical know-how are clearly important, but these must be presented with an excellent standard of communication skills" (p. 94). Therefore, besides a high level of technical knowledge, effective communication and literacy skills play an important role in delivering desired project results.

The Space Shuttle Challenger tragedy is but one example of how engineering has a direct and lasting impact on life. As a result, "literacy in engineering, including the rigorous interpretation, evaluation, and production of texts, can be very consequential" (Wilson-Lopez & Minichiello, 2017, p. 1). Although this might be true, there is evidence that engineers are often not good communicators, and there is a belief amongst them that they do not need to study English (Missingham, 2006). However, Missingham (2006) also found that "increased levels of communicative competence relate directly to employability and success in the engineering industry" (p. 348). Hence, the idea of a discourse community that shares knowledge, language and practices can be used to understand why communication skills are so important. Engineers do not express themselves in the same way as philosophers or lawyers. Hence, there must be a common way to engage with written texts (reports, standards, specifications, etc.) and visual material (charts, plans, maps, diagrams, etc). Without such a common language and without the ability to engage in discourse with each other, members of any such community cannot share their experiences and get things done (Hyland, 2008). Therefore, in order to adequately prepare engineers for their future careers, the inclusion of communication and literacy skills within the engineering curriculum is a crucial part of an engineer's education. Of particular significance are written and oral communication skills.

In respect of teaching writing skills, Hyland (2008) notes that written English tends to favour a more rigid structure and organisation than some other languages. In English, it is the responsibility of the writer to ensure clarity rather than the responsibility of the reader to find meaning in texts that can sometimes be vague and dense. He further argues for a genre approach to teaching professional writing. That is, that writing courses should focus on the linguistic knowledge and techniques that will enable the future competent performance of discipline specific learners. In this way, grammar is not so much about learning a rigid system of rules separate from any context, rather it is a suite of techniques that can be

deployed to achieve a particular purpose. By focussing on textual properties and structures (exposition, narration, argument, description, etc.) students can learn to produce their required professional genres (reports, research papers, etc) (Martin, 1992, as cited in Hyland, 2008).

When it comes to oral communication skills, Riemer (2002) argues that these are increasingly sought after by employers, but they are not explicitly taught in engineering courses. Indeed, at least one study has found that an overwhelming majority of practising engineering graduates were regularly required to provide oral presentations (Keane & Gibson, 1999). More recently, de Souza Almeida et al. (2019) found that oral communication is the preferred and most frequent method of communication within the four engineering disciplines they studied. Unsurprisingly, oral presentation skills are best learned experientially rather than didactically (Riemer, 2002) and there are many ways that this can be achieved. These can include learning activities such as: group presentations, video grading, role-plays, etc. Interestingly, direct instruction in communication technology such as MS Office applications is also useful (Keane & Gibson, 1999; Riemer, 2002).

Research shows that embedding the above communication and literacy skills into engineering courses and customising the teaching content to the needs of the profession lead to higher student engagement and better course outcomes. The subjects within the courses that incorporate communication and literacy skills are often known as English for Specific Purposes (ESP).

For example, in a car park redesign project conducted by seventh grade students at an American middle school, students were provided with a real-life project. They were tasked with engaging:

> *literacy practices similar to those used by engineers: gathering information across sources, cross-referencing multiple representations, prioritising criteria and constraints, and developing texts in the form of lists and tables to enable systematic tracking of whether and how future proposed design solutions meet the design requirements (Wilson-Lopez & Minichiello, 2017, p.9).*

The project involved discipline specific, authentic and relevant tasks. Third parties, such as expert family members, were invited to participate and contribute to the students' project to allow for a broader debate and demonstration of various communication and literacy skills. The authors concluded that engineering literacy was an essential ingredient for turning ideas into reality.

Another ESP project that supported the inclusion of discipline specific communication skills within engineering courses was undertaken at the College of Engineering at Shaqra University in Saudi Arabia. There at the College of Engineering, the curriculum for native Arabic speakers was changed to move away from studying classical English literature to focus on discipline specific needs for engineers. As a result of the course content and assessment redesign, there was "around 15% improvement in the student's English proficiency" (Alblawi et al., 2017, p. 154).

Both of these project outcomes align with research conducted within the English for Specific Purposes (ESP) discipline that "asserts that … uniquely tailored programs are far more efficient and effective for learners who require special skills to carry out highly specialised tasks for which general English may not prove sufficient" (Orr, 2001, p. 208).

Purpose

This project of customising a generic English subject into an ESP subject for first term engineering students was undertaken at Western Sydney University, The College, which provides pathway programs into Western Sydney University (WSU). The aim of this project was to establish the effectiveness of the discipline specific English communication subject,

Professional Communication Skills for Engineering (PCSE), for the Diploma of Engineering students.

English communication skills, which focus on the improvement of academic literacy through relevant and authentic discipline-specific content and genres, are an important element of transition pedagogy (O'Donnell et al., 2015; Kift et al., 2010). As a result, generic English subjects have been embedded into all diploma courses since the inception of Academic Pathway Programs (APP) at The College.

However, a recent increased focus on outcomes such as tutor and student feedback, and fluctuating student pass rates, along with the changing landscape of the professional industry resulting from the challenges of the pandemic where different professional skills became sought after, led to the discipline-specific customisation of all generic English subjects. Thus, in accordance with third generation transition pedagogy principles, *Professional Communication Skills for Engineering* (PCSE) was one of the first subjects rewritten to include industry specific themes and genres.

Methodology

The original generic English literacy subject for engineering students, *Introduction to Academic Communication 1 (IAC1)*, focussed on developing academic skills such as listening, note taking, summarising, and writing. The topics used as a vehicle to cultivate these skills were of broad interest such as what is more important for academic success, IQ or grit?

Following the decision to trial a replacement of IAC1 with an ESP subject for the engineering cohort, several industry texts and engineering faculty members were consulted in order to determine what were the most relevant and authentic communication genres that should be taught. Principal amongst these texts was Hansen and Zenobia's (2011) *The Civil Engineer's Handbook of Professional Practice*.

Arising out of this scoping stage, the following learning outcomes were developed:

1. interpret, analyse and describe data from graphs, charts and tables and identify and describe trends and differences.
2. demonstrate an understanding of engineering technical terms, abbreviations and acronyms.
3. identify and summarise main ideas and key information from written engineering texts.
4. plan and develop written and oral responses to authentic engineering tasks.
5. recognise language used to signpost main ideas and key information in lectures and record ideas and information using diagrams.
6. deliver a presentation and participate in a seminar using prepared notes.

Thus, the newly developed ESP subject, *Professional Communication Skills for Engineering* (PCSE) was to be focussed on communication skills and genres more immediately relevant and applicable to commencing engineering students. In respect of subject content, and again after consultation with engineering faculty members, the Snowy 2.0 pumped hydro project was selected as the focus of the new subject (https://www.snowyhydro.com.au/snowy-20/about/). This project has facets of a broad range of engineering disciplines (civil, electrical, mechanical, environmental, etc) and there is sufficient debate about its viability to ensure lively classroom discussion (Mountain & Lintermans, 2020). In particular, students are asked to compare the Snowy 2.0 project with the Tesla big battery (https://hornsdalepowerreserve.com.au/) from an engineering perspective. Lessons were often supplemented with communication skills practised on a variety of other topics such as: the difference between two-stroke and four-stroke engines, the effectiveness of green roofs, and the principles of double-glazed windows, etc.

Table 1 shows a comparison of the assessments for the two subjects. It can be seen that there is a shift in focus away from 'academic' communication genres (lectures and expository essays) towards communication genres more relevant for engineers (describing graphical data, describing processes, comparative technical reports, etc). Another notable difference between the two subjects is that while the generic subject, IAC1 had a final exam, this assessment was removed from PCSE and replaced with an authentic task that is more relevant to the discipline.

Table 1: Comparison of assessments for the generic English subject, Introduction to Academic Communication 1 (IAC1) and the ESP subject, Professional Communication Skills for Engineering (PCSE).

Week	Assessments for generic English subject, IAC1		Assessments for ESP English subject, PCSE	
3	Task 1: listen to a lecture on which is more important for academic success, grit or IQ? Answer questions and summarise the lecture.	15%	Task 1: describe and interpret visual and graphical data.	15%
5-6	Task 2a: write an essay plan for an expository essay on the topic of Task 1 or on the positive and negative effects of screen technology on cognitive development.	10%	Task 2: write a description of the pumped hydro process from audio visual prompts.	20%
7			Task 3a: write a plan for an engineering technical report that compares the Snowy 2.0 pumped hydro project with the Tesla giant battery.	10%
9	Task 2b: write a 1,000 word essay based on the plan in Task 2a.	30%	Task 3b: write an engineering technical report based on the plan in Task 3a.	30%
11	Task 3: deliver an oral presentation and discussion of Task 2b.	15%	Task 4a: deliver an oral presentation and discussion on an innovative engineering topic. Examples include the Tesla hyperloop, quantum computing, green hydrogen, living on Mars, robotics, etc.	15%
12-13	Task 4: complete a final reading and summarising exam on a topic broadly related to the content studied during the term.	30%	Tasks 3c and 4b: produce written learning reflections on Tasks 3b and 4a	10%

In the major assessment, Task 3b Engineering Report, students compare the Snowy 2.0 project with the Tesla big battery, and they choose a focus area of their own interest. This could be the environmental impact of the project, the design and operation of the reversible

pumps, the challenges of digging the tunnels, the issues associated with transmission of the power to market, etc.

For their Task 4a Oral Presentation, students are provided with a list of current innovations in engineering, and they are asked to explain the topic and lead a peer discussion. Topics include such projects as the Tesla hyperloop, quantum computing, green hydrogen, living on Mars, the future of robotics, etc.

After several trimesters of teaching the ESP subject, historical student results for all Extended Diploma in Engineering students who undertook the generic English subject between 2015 and 2017 were compared against those for students who undertook the ESP subject from 2018 to 2021.

765 individual student records (subject attempts) were examined. For each student, the data included such fields as: subject, grade, teaching period, and citizenship (domestic or international). Multiple subject repeats were recorded as a separate result for repeating students.

It should be noted that at The College, if a student does not submit a mandatory assessment, the student is automatically awarded a Fail Non-Submission (FNS) grade regardless of their overall mark for all other assessments. The data were collated into a single spreadsheet, and all grades were simplified to pass, fail, or FNS. Two data sets were analysed, one including both fail and FNS grades, and one without the FNS grades to distinguish genuine academic subject fails from fails resulting from non-submissions.

The data were summarised into tables and charts to search for evidence of longitudinal trends in English pass rates against such factors as term and inclusion of FNS grade. In particular, the data were examined for evidence of any changes in these trends before and after the ESP subject, *Professional Communication Skills for Engineering*, was introduced.

Actual and Anticipated Outcomes

In accordance with the findings of Alblawi et al. (2017), it was anticipated that there would be an improvement in student outcomes for those students who undertook the ESP subject compared to those who attempted the generic English subject.

Figure 1 shows the comparison of the number of students who attempted and the percentage of those who passed the generic English subject, IAC1, and the ESP subject, PCSE, for first term Extended Diploma students in Engineering for 2015 Trimester 1 – 2021 Trimester 3. The data include all fail grades, including FNSs.

The average pass rate for the generic literacy subject from 2015 - 2017 was 66%, with pass rates for individual trimesters in the range of 30% to 84%.

Similarly, the average pass rate for the ESP subject, *Professional Communication Skills for Engineering*, which has been offered since 2018 Trimester 1, was also 66%. The pass rates were in the range of 27% to 75%, with the lowest pass rate recorded in 2018 Trimester 2 for a class of students who were repeating the subject.

Overall, there was no significant difference between the student outcomes for the generic subject versus the ESP subject.

Figure 2 shows the breakdown of pass and fail rates for both the generic and ESP literacy subjects for first term students in the Extended Diploma in Engineering for 2015 Trimester 1 to 2021 Trimester 3. Students who achieved an FNS grade are excluded from Figure 2. As noted above, an FNS grade (Fail Non-Submission) is awarded to students who did not submit a mandatory assessment regardless of their total mark. That is, it is possible for a

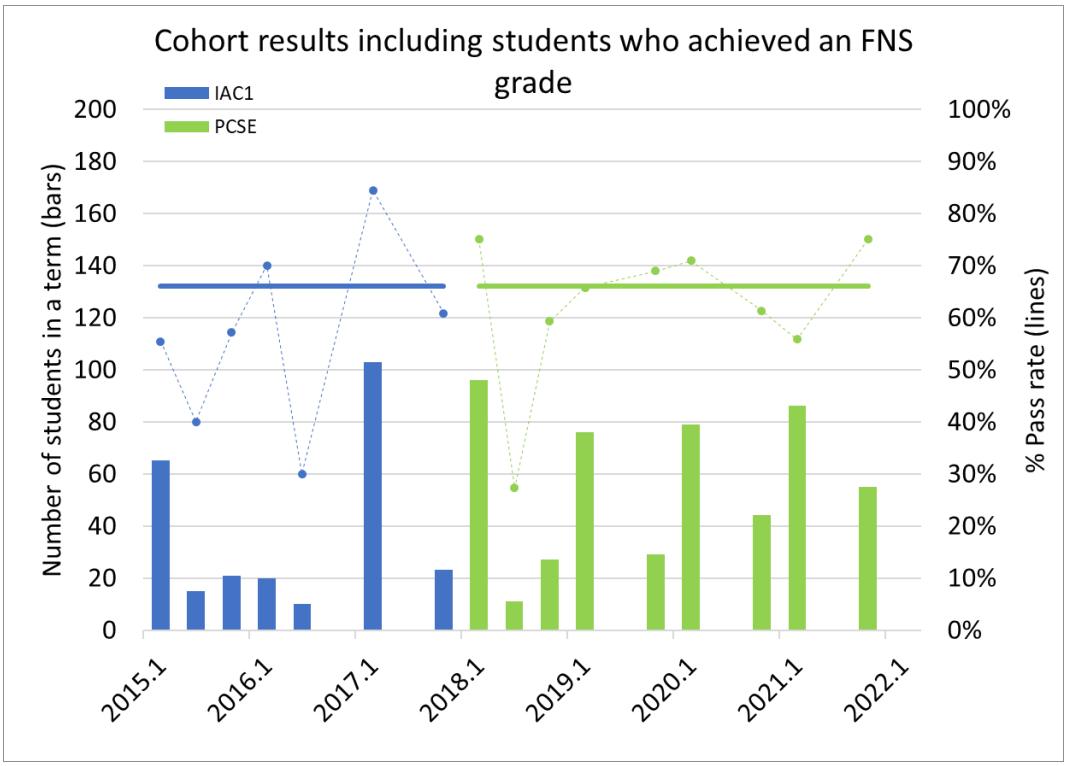

Figure 1: Comparison of pass rates of the generic English subject, IAC1, and the ESP subject, PCSE, completed by first term Extended Diploma in Engineering students between 2015.1 and 2021.3 including FNS results.

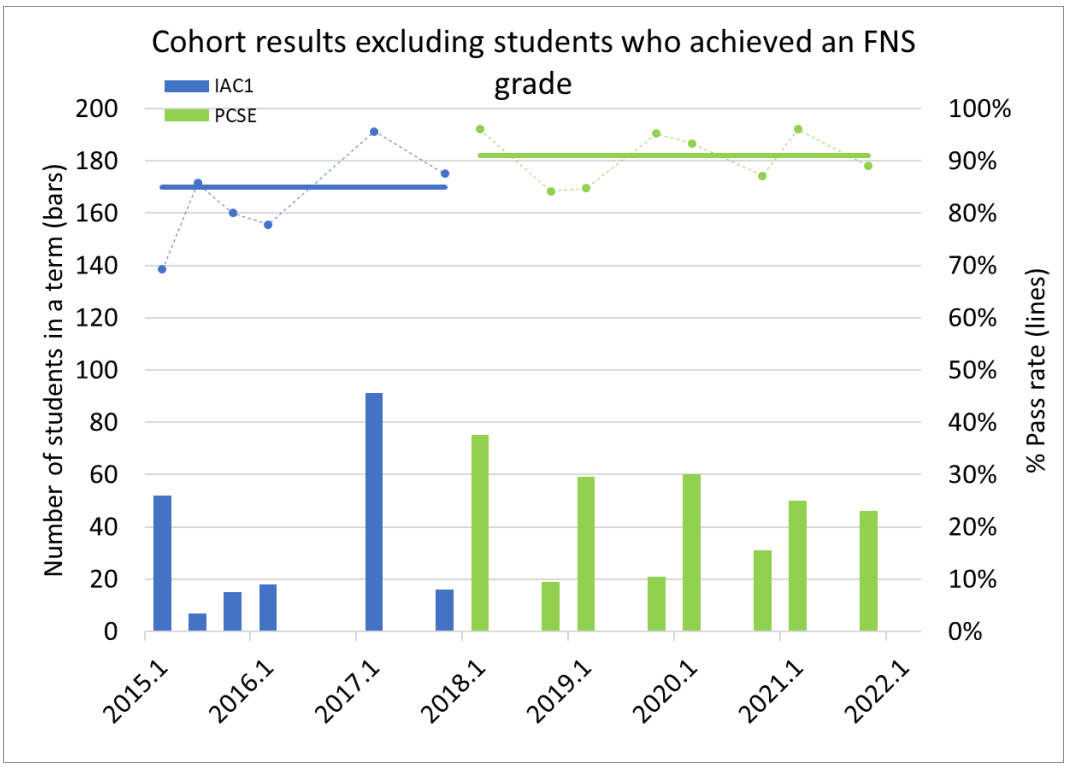

Figure 2: Comparison of pass rates of the generic English subject, IAC1, and the ESP subject, PCSE, completed by first term Extended Diploma in Engineering students between 2015.1 and 2021.3 excluding FNS results.

student to be awarded an FNS even though their overall mark is more than 50%. Generally, such students are those who have withdrawn from their course but did not complete the appropriate administrative process. Accordingly, they remain ‘enrolled’.

There are many reasons why students might withdraw late in the term, and the majority of these might not necessarily be related to academic issues (Greenland & Moore, 2021; Zhai & Monzon, 2001). Indeed, in many cases, the school might not be aware of the exact reason for such a withdrawal. Hence, it is appropriate to examine student outcomes after such students have been removed from the data. In this way, academic performance can better be assessed by itself.

The average pass rate from 2015 Trimester 1 to 2017 Trimester 3 was 85%, with the pass rates for individual trimesters in the range of 69% to 96%.

The average pass rate for the ESP subject, *Professional Communication Skills for Engineering*, from 2018 Trimester 1 to 2021 Trimester 3 was 91%. The pass rates were in the range of 84% to 96%. Consequently, an increase of 6% can be seen in the average pass rates for the ESP subject compared to the generic subject.

In summary, this study found that, the use of an ESP literacy subject in undergraduate engineering courses significantly improves student outcomes compared to a generic literacy and communication subject. This agrees with the findings of Alblawi et al. (2017) that discipline specific literacy education is more effective.

Conclusions

The development of the ESP subject, *Professional Communication Skills for Engineering* for first year engineering students resulted in a 6% increase in pass rates (when FNS rates were excluded) compared to the use of a generic English literacy subject. Thus, the approach of ensuring English literacy skills subjects for engineers are discipline specific and use relevant content, appears to result in significantly improved student outcomes. This result is consistent with the findings of other researchers in this field (Alblawi et al., 2017).

Reasons for these improved results may be the explicit relevance of the subject to the engineering-related experience and knowledge of students. For example, anecdotally, teachers report that classroom debate over the issue of the technical wisdom of the Snowy 2.0 project versus competitive technology such as the Tesla giant battery can get very animated.

Limitations

One of the limitations of the study was that any changes to the Australian Tertiary Admission Rank (ATAR) score requirements over the period in review were not included in this analysis. That is, fluctuations in students’ ATARs may impact the literacy level of commencing cohorts.

It should also be noted that the recent introduction of customised subjects coincided with the emergency transition to online delivery in response to the covid-related external circumstances.

Recommendations

To help ensure strong student outcomes it is recommended that generic literacy subjects be abandoned and that customised literacy subjects be developed for all student cohorts. Such subjects should address the needs of students’ chosen disciplines and be developed in collaboration with subject matter experts.

In addition, trends in the performance of repeating students should also be examined. Anecdotally, pass rates of repeating students tend to be lower, but this has not been quantitatively examined for impact on the overall subject pass rates.

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