

Design process for a communication skills program for Science and Engineering research students

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Structured abstract

CONTEXT

Engineering students need to develop skills in communication, and over the past several decades undergraduate programs have been augmented in line with this expectation (Russell, 2013). However, the need for postgraduate engineering students to develop skills to better communicate their research has not been addressed to the same extent, despite the fact that the demands placed on postgraduate researchers to write and present well in order to 'establish a professional identity' (Poe et al. 2010) are even more pressing than on those entering the field as 'working engineers'. The internationalisation of engineering education presents a further rationale for the creation of suitable postgraduate programs, given that many students now expect to enhance their English language proficiency over the course of their doctoral candidacy.

PURPOSE OR GOAL

In responding to these concerns, Swinburne University of Technology's Faculty of Engineering and Industrial Sciences (FEIS) has established a pilot program to address the question: '*How can FEIS higher degree by research (HDR) students be better supported in terms of the development of their research communication skills?*'

APPROACH

The approach to the program design involved conducting needs analysis, consulting with stakeholders within the faculty, considering issues and guidelines within the literature and drawing on the experience of the academic language and learning adviser in relation to previous writing and discipline-specific academic language and literacy programs.

OUTCOMES

The program that is currently under way includes the following components: seminars that model skills and strategies for engineering and industrial sciences research writing and presentation and that address the various stages of the HDR life cycle; consultation sessions incorporating focused analysis of students' writing and follow-up sessions to develop language and literacy skill; a range of online learning resources hosted on a dedicated website.

CONCLUSIONS

Mid-program evaluation indicates that a combination of targeted genre-based seminars and follow-up individual consultation sessions offers a promising avenue of improvement for HDR students seeking to enhance their research communication skills; however it is anticipated that further evaluation over the course of the program will add to current knowledge about the ways and the extent to which engineering students may expect to improve their communication skills over the course of their HDR studies.

KEYWORDS

STEM postgraduate communication skills, STEM doctoral writing

Introduction

In recent decades, there has been an increased focus on the need for science, technology, engineering and mathematics (STEM) research students to communicate well, as an important graduate attribute (Aitchison et al. 2012, Bastalich et al. 2010) and as a tool for the development of a professional identity (Poe et al. 2010, Austin 2010). The globalisation of science research, the way it is practised in multicultural teams and the status of English as the international language of science publication have also added to demands on STEM researchers' communication skills. These changes have affected the linguistic and cultural context for STEM research, from laboratory/teaching practice to virtual and mobile international teaming to multiple authoring of publications and proposals. Studies also point to increasing pressure on students to publish research articles before thesis completion (Aitchison et al. 2012, Moodie and Hapgood 2012).

Like most Australian universities, Swinburne University of Technology has expanded its cohort of international higher degree by research (HDR) students and in addition it has undergone a decade of rapid expansion of its research base, lifting its profile to that of a research intensive university of world class ranking in a range of STEM fields. In 2012-13, Swinburne University of Technology's Faculty of Engineering and Industrial Sciences (FEIS) introduced procedural changes to their HDR progress reviews. These included the standardization of progress review procedures among faculty research centres and discipline areas, and a need was perceived for a program that would support the rollout of this process, as well as addressing other issues related to communication skills among HDR students. The key questions that framed the program design phase were: *What are the needs of the faculty's research students in terms of their research communication skills?* and *What kind of program could best address those needs?* This paper reports on the design of the program that was developed as a response to these questions (including adjustments made early in its implementation phase) and identifies aspects of it that would warrant more empirical evaluation closer to the conclusion of its pilot phase. In particular it points to the need for further collaboration between communication specialists and supervisors in the STEM disciplines over ways to empower HDR students to better communicate their research.

Background to the program design

Needs analysis

Needs analysis for the project was undertaken using academic language and learning project management methodologies (White et al. 2008, Hyland 2003). This involved establishing a profile of the student cohort, investigating stakeholders' perceptions of students' needs, establishing the level of resourcing that could be provided and drawing on what is known about suitable HDR writing programs from the literature. The cohort comprised around 230 HDR students, 69% of whom were international students from a range of countries. Unfortunately there was no available data concerning linguistic background of domestic students; however it seemed that for a number of them, English was not their first language. For international students, entry into the program had involved satisfying English language proficiency requirements in various ways, including English-medium previous study, IELTS/TOEFL testing and 'English language intensive courses for overseas students' (ELICOS) pathways (Arkoudis et al. 2012). 26% of the cohort needed to undergo the Confirmation of Candidature Review faculty based progress review, with which many were unfamiliar, in the coming 9 to 12 months.

Before the establishment of the program, support for HDR students involved generic (i.e. non discipline-specific) seminars run by the university's central research office. Although ongoing language and learning support was offered to undergraduate students through a central support unit, this service did not extend to HDR students. Given these factors, the faculty decided to engage an academic language and learning specialist to design the program with FEIS HDR students in mind, and to run it over a trial period of one year. After the first three months the program's scope was extended to encompass the development of oral and visual communication skills; however, this paper focuses exclusively on the work the program undertook on the development of writing skills.

Faculty stakeholders identified a number of 'needs' in initial scoping discussions. The high proportion of international students and their relative lack of confidence in their writing were identified; a related concern was a perceived overreliance on editors to produce copy ready texts for journal articles and thesis submission. This was felt to be having a disempowering effect on students who were otherwise high achievers, overall, and the hope was expressed that, instead of encouraging students to put their writing into the hands of others, the program could help them gain a sense of ownership resulting from a higher level of mastery over their own writing.

The need for supervisors to be able to refer students for specialized assistance with HDR-level writing was another key requirement, and the hope was expressed that such a service would ease the burden of supervisors, who do not always feel equipped to deal with their students' writing problems (Aitchison et al. 2012, Jordan and Kedrowicz 2011, Kranov 2009).

The program was designed around three components: a series of targeted workshops and seminars, 1:1 consultation sessions and a learning management site (in the form of a Blackboard 'Organization') to host workshop materials and resources for independent learning. The aim of the workshops was to introduce students to genre requirements of their disciplinary area through analysis of sample texts and to engage them in writing practice in ways that would advance them towards their writing goals. Because of the changes to the Confirmation of Candidature procedures, the first series of workshops was targeted at addressing the written requirements of this progress review. However, it was planned that further workshops would address various stages of the 'life-cycle' of HDR candidates—articles for journal publication, further progress reviews and the stages of thesis writing. It was also envisaged that individual consultation sessions would support the workshops, in the form of feedback conferencing sessions, as well as addressing relevant concerns of students and their supervisors more widely.

Review of research into writing pedagogies

The program design followed recommended practice by taking into account findings from the literature about writing pedagogy and by synthesising elements from firstly, research into graduate writing¹ and secondly, research in applied linguistics and the teaching of English to speakers of other languages (TESOL) (Bastalich et al. 2010, Jordan and Kedrowicz 2011).

The graduate writing tradition

The key components of contemporary university-level writing program pedagogy are the modelling of discipline-specific genre and usage conventions and the exploration of writing as a process. Graduate writing programs have their antecedents in the forty year old North American 'rhetoric and composition class' tradition, which burgeoned into the 'Writing Across the Curriculum' and, more recently, the 'Writing in the Disciplines' movements (Russell 2002, 2013). In the North American arena, writing programs became a compulsory component of the 'freshman' year and over time were also integrated into later years, in some cases extending into graduate studies (Russell 2002, Poe et al. 2010, Jordan and Kedrowicz 2011).

Australian higher education largely followed the British tradition of rejecting compulsory or for-credit written communication classes in universities, instead developing various adjunct 'remedial' approaches. These have attracted criticism in recent years (Wingate 2006), resulting in calls for universities to offer extensive credit-based courses (Melles et al. 2005) or, as seems more likely, to 'embed' instruction of communication and academic literacy skills and developmental approaches to English language proficiency in undergraduate curricula (AUQA 2009). However, given the absence of coursework in Australian HDR studies, the remedial approach seems set to remain a feature of doctoral writing programs in this country for the foreseeable future.

Writing programs have also been enriched by European traditions of research into genre, which followed the work of Bakhtin (1981) in focusing on how an understanding of academic genres and their specific disciplinary features can empower student writers (Freedman and Medway 1994). Pedagogies organized around the development of audience awareness and the need to tailor

¹ In Australia, 'postgraduate' writing.

academic writing to achieve particular goals stem from the longstanding rhetorical tradition (Paré 2007).

Another very influential approach has been that of 'process writing', which began to be taught following research in the 1970s into cognitive and social processes exhibited by successful writers (Flower and Hayes 1981). This movement revolutionised writing pedagogy, dramatically expanding its field from a narrow preoccupation with model finished texts to a much broader examination of the varied and iterative practices leading to text production. Research into the writing process gave rise to pedagogies concerned with pre-writing strategies (such as brain-storming, mind-mapping, outlining and other planning activities) and post-writing strategies (such as revision, editing and various feedback seeking activities) in writing classes and in writing support groups. Research continues into behavioural factors affecting written output and the use of motivational strategies to stimulate academic writing (Silva 2007). 'Reflective' writing pedagogies and the notion of writing as a 'tool of thought' also stem from this tradition (Yinger and Clark 1981, Britton et al. 1975).

A new direction emerged in graduate writing programs from the 1990s as a result of increasing evidence that a 'discipline-specific' or 'content based' approach to academic writing can address the needs of students more effectively than a 'generic' approach. This is thought to be due to a more streamlined and intensive focus on the kinds of texts produced in disciplinary communities (Russell 2002, 2013). Interestingly, this approach has also had success in the field of language learning, where its benefits are thought to derive from the neural wiring potential of many more instances of staged and repetitive retrieval when learning is concentrated in a particular domain of knowledge, as well as factors related to salience and consequent reduction of cognitive load, relevance and motivation (Grabe and Stoller 1997).

Following the lead of MIT (Paradis 2010), discipline-specific writing programs were integrated into many U.S. STEM courses, both at undergraduate and postgraduate levels (Poe et al. 2010). In Australia, Liyanage and Birch (2001) argued for the greater efficacy of a discipline-specific approach in writing programs for 'English as an additional language' (EAL) university students. Confirmation of such findings in many other Australian and North American contexts (summarised in Arkoudis et al. 2012) led to the Australian Qualifications Framework's endorsement of a discipline-specific approach in their Good Practice Principles (AUQA 2009).

'English as an additional language' (EAL) writing pedagogies

The preponderance of EAL HDR students in the Swinburne Faculty of Engineering and Industrial Sciences meant that the program needed to be informed by writing pedagogies that support the development of English language proficiency. Research into academic language and learning programs in higher education is often described in terms of two geographically distinct strands: the British tradition of 'English for academic purposes' (EAP) and North American TESOL models.

EAP emerged as an influential practical teaching approach in Britain in the mid-1970s, offering remedial support to EAL students in English universities (Jordan 2002). Its methodology derived from so-called 'register' analysis of real world university tasks and from the 1980s it was increasingly influenced by research into genre and the notion of 'discourse communities' (Swales 1990). Its original aim was to encourage EAL students in English universities to perceive the English spoken in academic settings as a distinctive 'register', to model lexical, syntactic and discourse features of that register and to engage students in activities designed to help them recognize such features in academic texts and to reproduce them in their own academic practice. In keeping with its remedial focus, EAP has the additional function of inducting EAL students into a range of academic practices that are considered essential for their acclimatization, including the mechanics of referencing sources, time management and other so-called 'study skills'.

Criticisms of this approach have singled out its preoccupation with 'bolt-on skills' and its imitative practices and 'surface-level interaction with texts' in ways that are not always transferable to doctoral writing (Wingate 2006); however, especially when informed by a deeper engagement with discipline-specific textual analysis, EAP methods and resources are considered pedagogically sound and it is utilized extensively in the U.K. and in Australia, where it is particularly prominent in the field of ELICOS. A modified version of EAP—'English for specific academic purposes'

(ESAP)—emerged from the 1990s, following the influence of research into disciplinary differences in academic discourse mentioned above (Dudley-Evans 1998).

In the U.S., from the 1980s, TESOL methodology was more closely entwined with applied linguistics theory and debates concerning second language acquisition—in part over the testing of Krashen's 'Monitor Model' of language learning (Krashen 1981). The two aspects of the North American tradition that are the most relevant here involve research into the differences between writing produced by native and non-native speakers of English (based on analyses from the field of corpus linguistics) and writing pedagogy arising from Swain's 'pushed output' hypothesis (Swain 1985).

Applied linguistics research in the U.S. has built up a picture of wide-ranging differences between the kinds of practices and linguistic features that can cause problems in the writing of native and non-native speakers of English. Until the 1980s, TESOL writing pedagogies in North America were dominated by composition and process writing approaches, which had been conceived in order to address the needs of native speakers of English in their schooling and their early years of university. Such was the dominance of process writing that many of its tenets were unquestioningly applied to 'second language' (L2) writing (Hyland 2003). However, from the late 1980s, grammatical tagging of digitised texts added to the pool of available data, especially in relation to lexical and morpho-syntactic features of L1 and L2 writing (Hinkel 2011), and the picture that emerged showed that although both native and non-native speakers can experience difficulties in writing in a university setting, their difficulties are of a distinctly different nature.

In summarising what is known about the differences between L1 and L2 writing, Hinkel (2011) concluded that the much more pervasive sentence-level (i.e. words and grammar) errors in L2 writing are more likely to impede comprehension than typical L1 errors. This has implications for process-based writing programs, which have traditionally encouraged writers to postpone sentence-level correction until the final stages of editing. In science and engineering doctoral writing, early drafts of texts are often worked over in consultation with the supervisory and/or multiple-authoring team in order to cross check data, correlate detail and establish precise networks of relationships, and sentence-level mistakes that impede comprehension can interfere with this process.

One solution is to create separate or composite writing programs for both native and non-native speakers of English and to augment EAL programs with grammar instruction; however controversies in applied linguistics over explicit teaching of grammar made this a somewhat neglected area of TESOL in the 1980s and 1990s. In particular, Krashen's damaging hypothesis that the teaching of grammar does not assist (and probably interferes with) language learning caused a widespread hiatus in grammar instruction in language programs (Krashen 1981). By the mid-1980s, problems with the hypothesis began to be noted in studies of language immersion programs with no grammar teaching in Canada (Swain 1985). However, despite new approaches to the teaching of grammar (Long 1991, Hinkel and Fotos 2002), a problematisation of grammar teaching characterised the field for decades, resulting in a widespread de-skilling of educators.

Swain's research also revealed that postponing error correction in early drafts of EAL students' writing represents a lost opportunity for them to develop their English language proficiency through 'pushed productive output' (Swain 1985). Pedagogy in this field takes its cue from psycholinguistic research that shows that language learning is more durable when reinforced through the 'productive' channels of speaking and writing than through the 'passive' channels of listening and reading. This research also drew on the Vygotskian concept of 'scaffolding', which emphasises the to and fro of feedback channelling between learners and their teachers or language mentors (Vygotsky 1978). The related Vygotskian notion of the 'zone of proximal development' also informed Swain's approach, with its characterisation of language learning as an iterative process whereby feedback interacts with what the learner already knows about a language—their 'interlanguage'—and so helps to reshape each dynamic phase of language development.

Swain's socio-cognitive hypothesis is that this relationship works because the act of linguistic output exposes 'gaps', indicating to the speaker that they "cannot say what they want to say" (Swain 1995) and this 'noticing', subject to a successful 'pushed' scaffolding process, leads to better language

learning. Bitchener and Ferris (2011) have summarised influences of this research on corrective strategies used for writing feedback.

Findings from this field of research exposed the inadequacies of the 'learning by osmosis' expectations that had characterised many immersion-based approaches to language learning, including that of the first phase of intensive participation of international students in the Australian higher education system. Post-course testing of such students showed that a great many had not increased their level of English language proficiency over the course of their studies (summarised in Arkoudis et al. 2012). This realization brought calls for a much more interventionist approach to language learning in Australian universities and in 2009 the Australian Qualifications Framework produced a report that emphasised the developmental nature of the learning of language and highlighted the responsibility of universities for provision of ongoing academic language and learning support for both international and domestic students (AUQA 2009).

In sum, this roundup of research findings from the field of writing pedagogy provided a basis for the design of our program, suggesting that it should model genre requirements in a disciplinary setting, highlight relevant doctoral writing processes and demonstrate good writing practice. It also needed to take into account differences between the needs of EAL and non-EAL students and to develop English language proficiency in EAL students, in part by promoting pushed output accompanied by regular and appropriate feedback. The research also shows that mere immersion in the target language environment would not be enough to achieve our goals for EAL students, who sometimes need to be explicitly taught appropriate language features.

Action research and discussion

Action research conducted over the course of the program involved collection and analysis of program materials, including students' reflections and evaluations, and teacher reflection informed by 'critical friend' methodology (McNiff 2002). Study of the program after it was implemented identified various 'local issues' (Creswell 2008). The first was that students turned up for targeted seminars regardless of whether the session was designed for their stage of candidature or not. Seminars were very well attended (around 30% of HDR students had participated in at least one seminar by nine months) and there was a clear demand for the program; however participants in the first series—the Confirmation of Candidature writing workshops—were at very different stages of their candidature. A related issue was that participants were often not ready to write during the workshops and were not inclined to bring writing for peer review. Given the program's focus on process writing, in order to encourage pushed output among EAL students and to model good writing practice among all students (as discussed above), this was identified as a potential problem.

However, by midway through the program, the consultation service was running at capacity with 16% (21% by nine months) of faculty HDR students having accessed it (many of them multiple times) and it became clear that this was working better as a vehicle for process writing and pushed output than the seminars/writing workshops. From student reflections, program evaluation, and online learning management system metrics, it became apparent that HDR students were using the seminars, workshops and online resources to gain information about faculty procedures and writing requirements, structural and linguistic features of such texts, and the availability of support, and that, in addition, many were using the consultation service to obtain ongoing instructive feedback on their writing and their English language development.

In evaluating the needs of engineering doctoral candidates, Jordan and Kedrowicz claimed that students should be encouraged to "write outside of the [typical] write-submit-evaluate-revise cycle" (2011 p. 16); however study of this program indicated that an alternative (and unexpectedly successful) approach was to work with those pre-existing disciplinary cycles of required written production. As mentioned above, HDR students are already under pressure to increase their written output, in terms of progress reviews and publication in academic journals and in order to complete their theses in a timely manner. In our faculty, many students began factoring the consultation service into such cycles by making appointments with the academic language and learning adviser when they had a deadline coming up and using the practice of revising successive drafts to also work on improving their English language proficiency over the course of working up a text. Students

who were using the program in this way tended to be either those with well-developed independent learning skills and good 'word of mouth' networks, or those who had been strongly encouraged to participate by their supervisors, HDR advisers, faculty mentors or research article co-authors. In particular, the program benefitted students who were able to synchronise support from the academic language and learning adviser with supervisory feedback cycles, obtaining advice about grammar problems or other linguistic or structural issues with the text before conferencing with their supervisor over other matters, then returning to the academic language and learning adviser for consultation over subsequent drafts, returning them to their supervisor for further checking and so on. Student feedback indicated that this writing practice 'triad' could function well even when the supervisor and the academic language and learning adviser never met, although communication between them resulted in a more efficient 'division of labour'.

The role of supervisory practice in the development of STEM HDR students' writing has been under investigation in recent times (Jordan and Kedrowicz 2011, Kranov 2009, Austin 2010), although, as Aitchison et al. (2012) stated, much work remains to be done in this field. Austin pointed to recommendations from the Carnegie Initiative on the Doctorate project to 'go deep' into the disciplinary culture, in order to create innovative programs to improve STEM doctoral pedagogy (2010 p. 112). She also noted the Carnegie project's perspective that "disciplines have unique norms and cultures that influence the doctoral experience" and endorsed the project's research into values associated with stewardship, apprenticeship and multi-mentoring pedagogical models. Action research associated with our program showed that working 'with the grain' of writing and supervision practice of the research centres and discipline areas of our faculty helped our program to better address students' needs. However, more work could be done on optimising this aspect of the program and, in particular, this study underscores the need for further collaboration between writing experts and discipline supervisors to improve writing support for STEM HDR students at SUT and at other Australian universities.

Conclusion

In the context of increasing pressure on HDR students to improve their communication skills, a support program was designed to suit the needs of engineering and industrial sciences research students in our faculty. Students in the program used seminars and online resources to explore procedural, genre-related, rhetorical and linguistic features of appropriate texts and 1:1 consultation sessions to engage with the writing process and to develop their English language proficiency. Action research and preliminary evaluations indicate that the program is achieving its goals and that collaborative investigation involving faculty supervisors may offer ways to further enhance the HDR experience.

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