Integrating Writing and Structural Engineering – An Exploration

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Structured Abstract

BACKGROUND
Engineers do not need to know how to write. This statement expresses a common belief amongst engineering undergraduate students, which is often compounded by a resistance to communication practice. It is contrary to engineering industry and Engineers Australia Accreditation Board expectations, which value communication and rate written communication as a key competency required for engineers (Male, Bush and Chapman, 2009). Whilst communication skills appear to form an important part of engineering curricula, teaching these skills is often the responsibility of language specialists from a Humanities background. Collaboration between discipline lecturers and writing specialists has been the form of some interventions to enhance writing skills of undergraduate engineering students (Craig, Lerner and Poe 2008). However, communicating technological information involves interpreting and using specialised disciplinary discourse; content lecturers as disciplinary experts have a key role to play in teaching their students disciplinary discourse (Airey, 2011).

PURPOSE
This paper explores the realities of transforming engineering teaching practice within a core second year Civil Engineering unit of Structural Analysis to create space for teaching writing as disciplinary communicative practice through a strategic, enquiry approach to teaching and learning.

DESIGN/METHOD
The research was conducted as a case-study of a Civil Engineering second year core unit, Structural Analysis, at a large Australian onshore university, taught in Semester 1, 2013. The approach used is participatory action research and the data is analysed through interpretive methods.

RESULTS
The key outcomes of the change in teaching practice, assessed from University student survey data, confirm students' expectations for the unit did not include written language competency and resistance to assessment of communication skills. Challenges with implementation of the changes included development of tutoring staff competencies and confidence, and the provision of language-in-context learning activities, assessments and constructive feedback. Student feedback indicates they are more confident in writing, deconstructing questions and referencing. They have expressed enhanced understanding of the need for written communication skills in Engineering.

CONCLUSIONS
The conclusions are that the integration of written and oral communication skills is enhanced if the pedagogy transcends traditional teaching practices that view the teaching of engineering content as knowledge transmission. Teaching practice transformation required commitment from the University, discipline and language staff, and a modification in expectations of students. The resistance to communication skills may be mitigated by the input of engineering mentors to develop, present and assess real-world tasks for students which reflect the importance of communication skills alongside technical skills.

KEYWORDS
Engineering content and language integration; collaborative teaching; language skills in engineering

Introduction

"Engineers do not need to know how to write". This comment represents a common belief amongst engineering undergraduate students, and is often compounded by a resistance to communication practice. In fact, engineering students often choose the discipline as they perceive it to be one that does not require good language skills (Drury & Jones, 2010).This attitude is contrary to the expectations of the engineering industry and the Engineers Australia Accreditation Board which value communication and rate written communication as a key competency required for engineers (Male, Bush & Chapman, 2009).

The realisation of the importance of language and communicative skills was noted as early as 1996 when these skills were deemed as graduate attributes necessary for accreditation of engineering programs in Australia (Engineers Australia Accreditation Board 1996). As such, in light of industry and professional expectations, communications skills are now included in engineering curricula and are usually included as a key component in the first year of study. However, the teaching of communications skills in engineering is often the responsibility of language specialists from a Humanities background. There is a need to question this practice as it seems the reluctance of engineering teaching practitioners to teach communication skills in their disciplines mirrors the beliefs and attitudes of their students.

Goldsmith, Wiley and Boud (2012) propose that knowledge in engineering springs from a positivist epistemology that values knowledge as object. This idea of knowledge as object (Ellsworth, 2005) permeates much of what is understood about teaching and learning. Perceptions of 'knowledge as object' often overlook the role of language in the process of making knowledge. They assume that using language is a transparent process and that language can be used objectively to represent reality. However, it is important to understand that whatever we convey in language is only our interpretations of our experiences (Davis, Sumara & Luce-Kapler, 2000). These ways of using language are often specific to people who interact within a particular context (Gee, 2003). In other words, engineers have their own ways of using language and making meaning with language; these ways are a particular kind of social practice and as such, one needs to be 'apprenticed' in order to engage in this practice (Jacobs, 2010, p.61).

The notion of literacy as social practice views linguistic resources as being shaped through interaction with others in the same social context. Discipline specialists recognize the need for students to continue to develop their technical competencies at university; they also need to acknowledge the need for their students to develop their language skills. Discipline specialists often have limited understanding of the workings of language within their discipline which may appear as common sense knowledge – what Coffin et.al. (2003) refer to as 'invisible' knowledge. Discourse conventions are so deeply embedded within the psyche of the discipline specialist that its practices become routine (Aitchison, Catterall, Ross & Burgin, 2012). This is where the language specialist is required – to make these conventions explicit.

PURPOSE

This paper explores the realities of transforming engineering teaching practice within a core second year Civil Engineering unit. The transformation aimed to create space for teaching writing as disciplinary communicative practice through a strategic, enquiry approach to teaching and learning. We present the implementation strategies of this transformation and report on the results and challenges associated with it.

METHOD

Research Approach

The research was conducted as a case-study of a Civil Engineering second year core unit, Structural Analysis, at a large Australian onshore university, taught in Semester 1, 2013. The approach used is participatory action research. The main question that drives this study has emerged from the authors' own practical professional problems: How do we engage students to value communication skills as an integral part of learning Structural Analysis (SA)? How do we engage, equip and sustain discipline specialists to transform teaching practice to embed commination skills? Thus, the methodology used is one of self-reflection, coupled with feedback from students and other stakeholders. The data is analysed through interpretative methods.

Background of the project

We began collaboration after being introduced by a fellow staff member. X who is the discipline specialist was seeking for ways to improve her students' language ability. X was concerned about the ability of her students to articulate their conceptual understandings in worded short-answer questions. Y who is the language specialist was attached to the Learning Centre as the Science and Engineering Language and Learning Advisor. Although, there was widespread awareness and concern about students' language ability amongst the teaching faculty at the university, Y found that students were not attending language workshops organised by the Learning Centre. Thus began the collaboration in the hope that with our combined effort and strengths, we could be proactive about addressing the issue. We decided that the best way to engage students in developing their language ability would be by integrating language into SA content. Literature in the area suggests that there are strong reasons to believe that discipline-specific content affords opportunities for language to be acquired in a holistic manner (Weir and Storeyguard, 1996; Palinscar and Klenk, 1992; and Crandall,1987). However, the manner in which the content is taught determines the quantity and extent of opportunities. X's teaching approach which is student-centred was deemed as desirable for this purpose.

X was very aware of the need to ensure that sufficient instruction and practice was provided to students before the expected level of competency was assessed. This would require additional and specific language skills instruction and modelling. Upon reflection, X concluded that the expectations were not met because students did not receive language/ communication strategies instruction within the unit. Whilst communication learning outcomes were always articulated in the Unit Outline of SA, explicit instruction in these outcomes was not provided because it was assumed that students would be able to learn these skills through imitating language/communication strategies modelled by X.

Y based in the university's Learning Centre was seeking to offer students language/communication strategies through a developmental context. Research in the area shows that discipline specialist were often reluctant to refer students to 'academic literacy' advisors as support available through these means was often too generic (Hammond, Ryland, Tennant & Boud, 2010). Furthermore, students are reluctant to access this kind of instruction as it is often perceived as remedial or for non-English speaking background students.

We started the project with a series of brainstorming meetings in which the needs of the discipline staff member and students, and possible implementation strategies, were identified. We also studied the language of Structural Analysis (the English of SA) together and identified aspects of English usage that was particular to the discourse of SA. Subsequent to these brainstorming sessions, we examined the previous years' curriculum plan (unit outline) and identified when integration activities and assessment could occur

within the unit. In the course of this exercise, we realised that the original plan would need to be modified with respect to assessment. Based on our teaching experience and knowledge of students' attitudes towards language, we knew that students would not engage with the language learning outcomes if they did not have an extrinsic motivation factor that compelled them to do so. Thus, we decided to allocate a significant number of marks to the language assessment component of the written tasks. Historically the language aspect would have only counted for five percent of the total grade. We expected that this move to allocate more marks for language would be met with some resistance by students.

We were also confident that our collaboration was strategic as it met the university's initiatives for the development of students' language competencies and responds to the university policy which states, in part, that '[T]he University considers the development of English language proficiency to be integral to the development of discipline-based knowledge, and that language use varies according to context, audience and purpose…' (Z University 2013).

Implementation Strategies

The integration activities were to be delivered through student-centred teaching and learning as this would ensure meaningful language use and development. Language learning outcomes are only realised when students have meaningful opportunities for knowledge construction in the language, and this is not possible through transmissive or teacher-centred teaching (Ramiah 2007). Hence, the integration activities were mainly executed in workshops where activities were scaffolded to support students towards their assessment tasks (Table 1) .The workshops were for 1.5 hours and scheduled for each teaching week of the semester.

Table 1 Assessment Tasks and Grade Allocation as Percentage of Semester Grade

Task	Grade Allocation (%)
group essay	6
individual short answer	6
individual short answer	6
mid-semester test short answers	7
final examination short answer components	5

Whilst it may appear that the teaching was assessment driven, this was not the case. We decided that by attaching substantial marks to tasks that were significantly writing-based, students would be compelled to take the language aspect seriously. The integration activities were scaffolded and carried out during the workshops. Students were required to participate actively and several feedback loops were structured into the activities to ensure students received appropriate feedback with respect to discipline content and language used to communicate that content. In this way students were able to practice and develop understanding of expectations before they were assessed. For example, in the group essay task, students were asked to form groups of five. They were then presented with a simplified real-life SA problem and were asked to analyse the problem for the following aspects:

a.   Load path / Estimate of Actions (loads)

b.   Support types / Estimate of Reactions

c.   Structural type and Determinacy / Materials or Sections choices

They were required to present their analysis in an essay and then share their essay with the class. Their classmates were asked to critique the solution with respect to the technical elements and clarity in regards to use of language. This was followed by comments by the both of us as discipline specialist and language specialist. In this way we managed to ensure that students were given appropriate feedback on both language and content.

Concurrent with the integration activities, explicit instruction in both technical content and language was provided via a number of different mediums such as lectures, workshops, online resources, exemplars and video recordings. The both of us engaged in team teaching when it was practical to do so. This effort required regular meetings where we reviewed and reflected upon our teaching strategies and assessment practices. Our reflections allowed us to refine our approach for future face-to-face sessions with the students and adjust assessment. Students were also encouraged to take responsibility for their learning through attending workshops and classes run by the Learning Centre.

We also had meetings with the tutors (all discipline specialists) to explain our approach. The first workshop of each week was attended by all tutors in the capacity of learners so that they could immerse themselves in the learning experience and shadow the discipline and language specialists. This was to enable tutors to provide appropriate feedback to students in subsequent workshop sessions to achieve the desired learning outcomes.

Results and Discussion

Student Perceptions and Outcomes

University administered and collected data of student perceptions was analysed to assess the impact of implementation. Assessment of qualitative and quantitative data was undertaken. The items and unit agreement rates from 2008 to 2013 are in Table 2. Historical data was used from 2011-2012 to compare with data from 2013. Student agreement rates are the percentage of students who respond that they strongly agree or agree with the item.

Table 2 XX University Quantitative Items Historical Data

	Quantitative Items	Student Agreement Rates (%)		
		2011	2012	2013
1	The learning outcomes in this unit are clearly identified.	94	94	85
2	The learning experiences in this unit help me to achieve the learning outcomes.	87	93	87
3	The learning resources in this unit help me to achieve the learning outcomes.	84	85	76
4	The assessment tasks in this unit evaluate my achievement of the learning outcomes.	87	90	87
5	Feedback on my work in this unit helps me to achieve the learning outcomes.	77	74	81
6	The workload in this unit is appropriate to the achievement of the learning outcomes.	86	90	90
7	The quality of teaching in this unit helps me to achieve the learning outcomes.	81	81	81
8	I am motivated to achieve the learning outcomes in this unit.	83	92	84
9	I make best use of the learning experiences in this unit.	83	89	87
10	I think about how I can learn more effectively in this unit.	83	86	82
11	Overall, I am satisfied with this unit	85	84	82

Three items experienced significant shift in unit satisfaction as illustrated in Figure 1. The reasons why significant shifts occurred are hypothesised below, given that 2011-2012 had minimal change to the unit delivery.
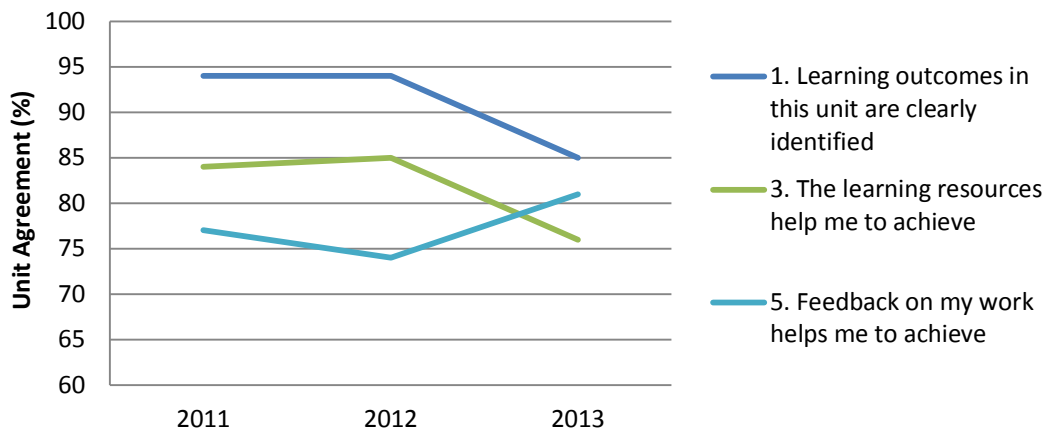
Figure 1 Significant Change Items Trends 2011-2013

As seen in Figure 1 agreement rates decreased significantly for Item 1 which was "learning outcomes in this unit are clearly identified". This was unexpected given the learning outcomes were relatively unchanged and were simplified in 2013. The communication focused learning outcome changed only slightly from 2011-2012 from "effectively communicate an understanding of structural analysis of statically determinate and indeterminate beams" to 2013 "effectively communicate structural analysis concepts and applications". One reason for the decline in satisfaction with the clarity of learning outcomes could be attributed to the emphasis on peer learning and communicative practice. Some students met the move with resistance and qualitative feedback included comments such as:

The workshops initially were a good idea, but they mostly consist of learning how to write essays rather than the actual content of the unit. I would rather do tutorials than do a workshop, as I feel I didn't learn as much as I could in these workshops.

There is a need for a tutorial! The workshop was a poor excuse for a tute. There is a definite need for one as students were very confused with various problems.

Change the workshop class back to normal tutorial class. Run a proper tutorial

Writing was unexpected and came as a bad shock

However, some students responded positively to the shift agreed that the workshops helped them achieve the learning outcome "effectively communicate structural analysis concepts and applications". The aim to embed language instructions and skills within the discipline context appeared successful as there was agreement that the unit taught communication skills as part of Structural Analysis theory and application. Comments include:

I also found that the workshops were useful in helping learn and review the unit's content.

Workshops are the best giving as an idea of what happens in real world by enhancing our communication- Not only our maths.

I expected the usual tutorial session, but the workshops were developed to be more learning-effective, and enhanced communication skills.

> *The communication also put a realistic aspect on structural analysis and allowed for thought on why members were acting in ways that they were.*

Although, the inclusion of language instruction was unexpected, students seemed to value the input provided in this respect. Students commented:

> *There was a portion dedicated to communication skills, which I feel contribute more to our overall learning, and broadens our knowledge and capabilities as student engineers.*

> *Good that the importance of good writing/communication skills was emphasised.*

> *The communication skills also put a realistic aspect on structural analysis and allowed for thought on why members were acting in ways that they were; as well as being able to put into words what was happening to structures.*

> *I expected the usual tutorial session, but the workshops were developed to be more learning-effective, and enhanced my understanding and use of communication skills.*

Figure 1 shows the drop in agreement rate was for item 3 which was "the learning resources help me to achieve the unit learning outcomes". The authors had provided resources to support English instruction. Feedback on these resources was largely positive. Concerning analytical-focussed resources, a shift in 2013 occurred with the provision of fewer lecture notes and an essential text with on-line learning resources. The decrease in agreement with item 3 may be attributed to the change in resource delivery for the technical content. Students resisted purchasing a text and commonplace comments were:

> *Provide lecture notes like previous years instead of telling students to buy the useless book!*

Figure 1 shows the increase in agreement rate was for item 5 which was "the feedback on my work helps me to achieve the unit learning outcomes". The authors instituted a feedback loop which involved peer interaction and responses. Means of providing feedback were highlighted by students as positively affecting their ability to achieve the learning outcome. However, some students still felt that more direct and personal feedback was required:

> *Constructive feedback on our own work rather than reflections of what other class members did.*

OUTCOMES

The key outcomes of the change in teaching practice, assessed from University student survey data, confirm students' expectations for the unit did not include written language competency and indicated resistance to assessment of communication skills.

Challenges with implementation of the changes included development of tutoring staff competencies and confidence, and the provision of language-in-context learning activities, assessments and constructive feedback.

Student feedback indicates they are more confident in writing, deconstructing questions and referencing. They have expressed enhanced understanding of the need for written communication skills in engineering.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The conclusions are that the integration of written and oral communication skills is enhanced if the pedagogy transcends traditional teaching practices that view the teaching of

engineering content as knowledge transmission. Teaching practice transformation required commitment from the University, discipline and language staff, and a modification in expectations of students. The resistance to communication skills may be mitigated by the input of engineering mentors to develop present and assess real-world tasks for students which demonstrate communication skills. This strategy, implemented in semester 2, for a number of Civil Engineering units has received positive feedback from students and industry participants.

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