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How can writing develop students' deep approaches to learning in the engineering curriculum?

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BACKGROUND

Recent national and international research has identified a number of gaps in the development of engineering graduate capabilities: one is the real-world problem-solving ability, which is linked to a lack of integration of theoretical and practical knowledge (ASEE 2009; King,2008; Royal Academy of Engineering, 2006; Sheppard, Macatanga, Colby & Sullivan 2009; Male, Bush & Chapman 2009; Walther & Radcliffe 2007). Another is written (and spoken) communication (King, 2008; Male, Bush & Chapman 2011). There is strong evidence to indicate that these gaps occur in part as a result of a predominance of engineering curricula in universities which emphasise knowledge acquisition, and the prevailing assessment tasks that focus learning on atomised pieces of knowledge. Such an approach encourages surface learning approaches, resulting in graduates who may lack the integrated knowledge required for engineering practice and who have limited communication capabilities.

PURPOSE

There is, however, a body of research that suggests deep approaches to learning in the disciplines can be achieved through particular kinds of writing that provide the opportunity to explore concepts which link theory and practice, thus developing both writing ability and integrated understanding. This paper presents the preliminary phase of a study to investigate the strategic use of discursive writing to foster both a deeper approach to learning and enhanced written communication skills in the engineering curriculum. The study focuses on discursive writing as a means of providing students with the opportunity to explore the theories and concepts that they are learning, in order to integrate knowledge from different parts of the curriculum and to link the theories to engineering practice.

DESIGN/METHOD

In order to investigate how writing is currently practised and assessed in Australian engineering curricula, a preliminary analysis of written assessment tasks in a unit of study in the mechanical engineering program from two Australian universities was undertaken. The analysis focused on the types of writing that students are required to produce and the extent to which writing is practised and evaluated.

RESULTS

The results have been analysed with a view to responding to the following questions: what is the range of writing tasks that students produce? The limited range of writing tasks suggests that there is a need to develop broader number of genres within the curriculum. Is there evidence of explicit teaching or learning activities centred on writing? The analysis revealed that there was little to no evidence of explicit teaching and learning of writing, suggesting that writing is being assessed but not taught in the engineering curricula being examined.

CONCLUSIONS

The understanding gained from the analysis will form the basis for the later phases of the study, which will seek to discover how students and staff view writing and integrated knowledge. From this, a number of writing tasks will be developed and subsequently piloted to determine their effectiveness in developing students' writing capabilities and facilitating integrated understanding of the engineering curriculum.

KEYWORDS

deep approaches learning, writing tasks engineering, engineering graduate capabilities

Introduction

Recent national and international research has identified a number of gaps in the development of engineering graduate capabilities: one is real-world problem-solving ability, which is linked to a lack of integration of theoretical and practical knowledge (ASEE 2009; King, 2008; Royal Academy of Engineering, 2006; Sheppard, Macatanga, Colby & Sullivan 2009; Male, Bush & Chapman 2009; Walther & Radcliffe 2007). Another is written (and spoken) communication (King, 2008; Male, Bush & Chapman, 2011). There is strong evidence to indicate that these gaps occur in part as a result of a predominance of engineering curricula in universities which emphasise knowledge acquisition, and the prevailing assessment tasks that measure the learning of atomised pieces of knowledge by means of short answer quizzes and examinations.

The current delivery of the engineering curriculum in the majority of Australian universities reflects a positivist epistemology (Radcliffe, 2006) which values propositional knowledge-knowing about things, or 'knowing what' (Biggs & Tang 2007, p.73). As previously noted, this epistemology places emphasis on knowledge acquisition; it is generally aligned with educational beliefs that knowledge is seen to be externally constructed, or an independent entity, (Samuelowicz & Bain 2001) and focuses on the transmission of knowledge from lecturer to student. The acquisition of this knowledge is measured by how well students can reproduce it under exam conditions; this has a number of unintended consequences.

Firstly, it inadvertently encourages surface approaches to learning, as students tend to rote learn in order to cram in knowledge for exams. This in turn can mean that the knowledge is lost once it is no longer needed for the exam. In addition, students themselves recognise that exams are not the best measure of learning, as indicated in the following quotation from an engineering student: "exams – they're not realistic. You don't sit in your office at work and you have 3 hours to complete these questions and you can't reference a text book" (Goldsmith, Reidsema & Campbell, 2010). This would also call into question the face validity of this knowledge for students: if it only needs to be memorised to be reproduced in an exam, how necessary is it?

Secondly, as the major (and in many cases, only) forms of assessment in many units of study are quizzes, tests and final examinations, students do very little writing. This, intentionally or not, devalues writing - both the capability to communicate in writing, and the learning that comes from writing. A related issue is that when engineering students are required to write as part of their assessment, there is often little guidance about what or how to write; assessment criteria can be ambiguous and feedback from lecturers can be less than constructive. The outcome of these practices is engineering graduates who lack the integrated knowledge required for engineering practice, and who have limited communication capabilities.

And yet there is abundant evidence and research that points to how much writing engineers, both practising engineers and engineering academics, actually do as part of their work. Winsor (1990) makes the point that writing is viewed as part of an engineer's job, but not part of engineering (p.58). However, despite the perception that engineers have of themselves as people who work with objects, "writing is what engineers do" (p.68). In his study of the gaps between engineering education and practice, Trevelyan reports that newly graduated engineers spend 60% of their time interacting with other people, and just under half of the interactions are in writing (Trevelyan, 2010, p.383). Engineering academics are expected to write for publication as a major part of their workload, not to mention any grant applications or research proposals. The importance of written communication for engineers is also noted in the King report (King, 2008) and in a recent study on generic competencies for Australian engineering graduates (Male, Bush & Chapman, 2011).

Purpose

It is then necessary to consider why, when so much in the professional engineering domain, not to mention the academic engineering domain, incorporates or is only to be achieved by writing, is the act of teaching and assessment of writing so undervalued by engineering academics? Perhaps part of the explanation lies in the mode of knowledge and the predominant approaches to teaching in engineering. The argument advanced by Johnston, Lee and Macgregor is that "engineers are accustomed to working only within their own discourse, where it is assumed that the engineering facts speak for themselves" (1996, p.2). Carter Ferzli and Wiebe (2007) point out that in the traditional model of educational practices, writing is portrayed as separate from knowing. It is probably fair to say that this is the case in most engineering schools in Australia, given the value accorded to "technical knowledge, discovered using a reductionist research paradigm" (Radcliffe, 2006 p. 263).

It is almost a commonplace to state that engineering faculty staff are uncomfortable with assessing writing within their discipline, let alone teaching it, but it remains a key requirement. Certainly, amongst the four year degree programs, the majority of students are expected to produce either an honours thesis or a non-thesis project, consisting of several thousand words, yet faculty staff resile from teaching writing specifically or from identifying what is meant by "good writing" except to say it should be "clear". In all of this, with the separation of knowing from writing, and the emphasis on atomised pieces of information rather than on writing as a way of representing what has been learned, there is a loss of integrated understanding. Engineering students often struggle to link theory to practice, or to see how what is learned in one unit can be transferred to another circumstance.

There is, however, a body of research that suggests deep approaches to learning in the disciplines can be achieved through particular kinds of writing that provide the opportunity to explore concepts which link theory and practice, thus developing both writing ability and integrated understanding (Brown, Collins, & Duguid,1989; Herrington,1985; Lea & Street, 1998). These approaches emerge from a range of theoretical perspectives. Writing in the disciplines (WID) is based on a constructivist framework that sees knowledge as being co-constructed by teachers and students, and where students construct their own meanings from information and past experiences (Biggs & Tang, 2007). In the WID approach, the student writer is being socialised into the expert writing of the discipline; it shares many commonalities with situated learning (Lave & Wenger, 1991), both in regard to novice practitioners learning by peripheral participation in the practices of the community (or discipline) and "the view that agent, activity, and the world mutually constitute each other" (p.33) so the context in which the learning takes place is critical. There are also strong links to the theoretical perspective of situated cognition (Brown, Collins & Duguid, 1989), which stresses the importance of learning in context and of students performing authentic tasks. Brown et al. critique much institutional learning because the learning activities are often decontextualised and inauthentic …"students can often manipulate algorithms, routines and definitions they have acquired with apparent competence and yet be unable to apply them to a real-world situation" (1989, p. 33). In situated cognition the writer is seen as an apprentice within the writing process.

Academic literacies (Lea & Street, 1998) is a theoretical perspective which builds on the WID approach but which attempts to problematise the role of the writer and the types of writing required of the student. It appears to be one of the few approaches that challenge the power dynamic in academia, where the tutor/lecturer has authority while the students are expected to follow instructions without challenging them. It invites student writers to question what they are required to write, the genres that they are expected to command, and the ways in which their writing is assessed, based on disciplinary expectations which are often implicit or ambiguous.

There are several examples of engineering curricula both in Australia and in the US which incorporate writing tasks into the engineering curriculum for enhanced understanding of

concepts, for example Lord (2009), Oehlers and Walker (2006) and Wheeler and McDonald (2000). In addition, the importance of writing in engineering has been evidenced by several Australian Learning and Teaching Council (ALTC) projects in Australia which seek to develop student writing abilities, such as the WRiSE site (Write Reports in Science and Engineering) (2012) and the iWrite initiative (2012). However, these approaches tend to focus on the typical genres encountered in engineering, such as lab reports and design briefs.

The purpose of the current study is to explore the extent to which discursive writing – writing which considers different points of view and synthesises arguments – can develop deep approaches to learning and students' writing abilities in the context of the engineering curriculum. It is proposed that if students are provided with the opportunity to write discursively about what they are learning, they may be able to develop a deeper understanding of what they are learning and be able to synthesise this knowledge and apply it to different topics.

Design/method

The first step in the process of investigation has been to discover where writing tasks occur in the curriculum and what types of writing tasks engineering students are required to produce. This has been done by examining the program of mechanical engineering at two Australian universities, identifying units of study that have stated assessable writing tasks, and analysing the writing tasks for purpose. Assessment criteria have also been examined to investigate clarity of instructions. In the next stage of the study it is intended that faculty staff and students will be interviewed to discover whether there is a shared understanding of what is required to fulfil the writing task, but this is pending ethics approval. Following on from the interviews, samples of student writing will be analysed using systemic functional linguistics to identify the level of appropriacy of the discourse, before moving into the later stages of the study.

Results

This paper presents the initial findings of the preliminary study that will be used to inform the direction of the ongoing research. In reporting these findings we attempt to answer the following questions: what is the range of writing tasks that students produce? If it is a limited range, what does this tell us about developing a broader number of genres within the curriculum? Is there evidence of explicit teaching or learning activities centred on writing? If not, what does this suggest about assessment of writing in the engineering curriculum? As part of this study, an analysis of units of study in first year engineering at two Australian universities shows that there is no writing required by the students for six of the eight units (University A) and for seven of the eight units (University B). Up to 90% of the assessment in the units is in the form of quizzes, mid-semester tests and final examinations. Lab reports are included in the assessment (generally 3-4 reports, weighted at 2.5%-3% each, totalling 10-15% of the final mark) but take the form of a series of results recorded from observing experiments. In one example marks are allocated for "preliminary analysis, results obtained and calculations made" (University A Unit outline XXXX, 2012, p.7). The situation remains the same for the second year at both universities. The only units that do have writing are the design units (University A has a general education elective which may include writing).

When writing tasks are set as assessments, there tends to be an assumption that the students will understand what is expected in terms of genre, audience, structure. However, as reported in other studies, such as Herrington (1985) and Hilgers, Hussey and Stitt-Bergh (1999), often there is neither a shared understanding, nor are there clear guidelines about the purpose of the writing. The writing tasks range from those that require students to assume a role, and perceive an audience as their employer or their client for whom they are writing a submission or report, to lab reports (which in themselves can cover a very broad spectrum of writing requirements), to design briefs (as in many common first year units of

study) to reflections on how they or their team could have improved their project. A shared feature of many of these tasks is that while grammar, punctuation and 'professional presentation' are often stipulated as assessment criteria, there is rarely any specific teaching or learning activities for the students to develop their writing capabilities. Similarly, the students are expected to present writing assignments in the appropriate genre (design brief, lab report, design proposal) usually without either a model to follow or information on what elements of the genre are required.

The assessment criteria for the written assignments can often best be described as opaque (and occasionally non-existent), for example: "understanding the relationship between the theory covered during the lectures to experimental results in the laboratory" (University A, 2011,Laboratory report, Unit outline AAA, p.5). There is no indication of how this understanding should be demonstrated, nor what the word length should be. In order to obtain a distinction for the introduction section in an evaluation report for a design project at University B, the following criteria apply: "Very Good information provided about the Project. Sentences were well written" (University B, 2012, Assignment 1, Learning Guide BBB,p.31). Vague or unclear terms used by engineering faculty staff to describe student writing problems are also reported by Jenkins, Jordan and Welland (1993); they make the point that "a person may have excellent knowledge of a language but be unable to identify objectively the language functions that mark logical relationships for 'clarity'" (p.63). The ambiguous phrasing of the criteria is not only the domain of engineering faculty staff, however. As Lea and Street point out in their study of student writing in higher education (1998), while many staff emphasise the importance of 'structure', 'argument' and 'clarity', they are often unable to describe what constitutes such a piece of writing, or how writing might lack structure. One lecturer is quoted thus: "'I know a good essay when I see it, but I cannot describe how to write it" (1998, p.163).

Another problematic area of student writing lies with the description of the assignment task, and relates to the following aspects: *audience, purpose,* and *content* (Herrington, 1985). Engineering students are often set assignments which claim that the intended audience is an employer or client, presumably to add context and authenticity to the assessment task. Authenticity of context is important but can frequently cause confusion when it is spurious, as the students are left unsure of a number of specifications such as assumed knowledge of the client, required breadth and depth of information to be provided and level of expertise of the audience. Similarly, the purpose of such an assignment can be obscured when the audience is purporting to be professional but is in fact for the lecturer: does the student write to display their knowledge to the lecturer or to solve the problem for the putative client/employer?

In order to provide a snapshot of typical writing tasks in the first year of the engineering curriculum at both universities, the analysis of one writing task from each university will be presented.

University A: *final report [for a product development project]: 20% (group submission).* There are no details provided for the format, purpose or length of the report: students are referred to the standard specification for assignments for the School, which are available from the School office. The following information is included: "All submissions are expected to be professional, and clearly set out. The submissions must be made in a proper folder so that the pages will not be missing (no stapling allowed!!!) [emphasis in original]. It is obviously critical that stapling not occur. It is to be assumed that other critical information, such as word length, format, purpose of the report and its intended audience, is conveyed in the lectures. An examination of the lecture schedule shows that there is a lecture/tutorial in week 10 (of a 13 week semester) on feasibility report writing; the report is to be submitted in week 13. No other information is available.

University B: *evaluation report [for a design project]: 25% (5% team, 20% individual;* "submitted individually by each student even though the [project] was constructed as a team". The format of the report is specified, as is the presentation – including font type and

size - but there is no mention of any word limit. The assessment criteria are detailed but not necessarily helpful (see above quotation); for the discussion section of the evaluation report, in order to achieve a high distinction it needs to be: "*Excellent summary of the results obtained from this project and comparison between calculated and theoretical values. All writing is clear and without spelling or grammatical errors – very professional"* (p.34). One would hope that professional writing could be something more than good spelling and grammar; in addition, there is no explanation or sample of what "clear" writing is. There is no mention of a report template or sample report for the students to consult, and there is no available evidence that lecture or tutorial time is given to developing student report writing abilities.

To return to the questions posed earlier in this section: the range of writing tasks that students produce is limited to reports that present either an analysis of the feasibility of a product – University A, or an evaluation of a design – University B. There could certainly be a broader number of genres in which the students could start to develop competence, such as arguing the merits of a particular design, approach, or selection of materials. There was limited evidence in the case of University A of explicit teaching or learning activities centred on writing, although one lecture/tutorial in week 10 seems to be too little too late. In the case of University B, there was no evidence of explicit teaching or learning activities, despite the comment in the learning guide that "The evaluation is the most important part of the report" (University B, 2012, Assignment 1, Learning Guide BBB,p.18). It thus appears that writing is being assessed but not taught. However, the unit outlines for both universities claim that the learning activities will develop graduate attributes associated with communication: "the skills of effective communication" (University A), and "Ability to communicate effectively, not only with engineers but also with the community at large" (Engineers Australia Graduate Attribute 2a 2007); "Commands multiple skills and literacies to enable adaptable lifelong learning" (University B). They are not the only unit outlines (or universities) that claim to develop graduate attributes without associated teaching or learning activities (Goldsmith, Reidsema, Beck & Campbell, 2010), nor are they the only units of study to lack constructive alignment in what is taught, learned and assessed (Nightingale, Carew & Fung, 2007). What this indicates very clearly is the need to ensure that where writing is assessed in the engineering curriculum, there are also specific learning activities to scaffold the writing, and that the assessment criteria are clear, transparent and achievable within the timetable of the unit.

Conclusions

As the findings presented in this paper are only preliminary, it would be premature to draw any firm conclusions. However, what is apparent even from this early stage is that there is much scope for the development of student writing abilities in the typical Australian engineering curriculum beyond what is currently being undertaken. There is also an imperative for engineering academics to see writing as part of what they do, and therefore part of what they should teach, in order to develop the graduate capabilities of the engineering students for whose education they are responsible. The study will continue to investigate writing in the engineering curriculum. As indicated earlier the next stage is to explore attitudes to writing from both a student and a staff perspective, before attempting to implement a range of discursive writing tasks that can develop a deeper understanding of the learning in engineering.

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