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The otherness of writing in the engineering curriculum: A practice architectures perspective

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Engineering students are expected to graduate with high level written and oral communication, yet these expectations continue to fall short despite repeated calls by industry and by accrediting bodies such as Engineers Australia for engineering faculties to address this issue. One explanation for this ongoing challenge is that the prevailing practices of engineering education constrain rather than enable the development of writing practices in the engineering curriculum, in part because writing practices are viewed as 'other', and as not belonging to engineering knowledge.

We argue that the reasons for the view of 'otherness' of writing practices in the engineering curriculum relate ontologically to the construction of engineering identities, and epistemologically to perspectives of engineering and writing as being different types of knowledge. Drawing on elements of identities of engineering educators and students, research on engineering knowledge and legitimation code theory, the authors explore these ideas through the lens of practice architectures theory. The analysis reveals that dominant practices in engineering education place writing practices outside what is seen to be engineering, although there are exceptions.

The authors conclude that the practice architectures of the engineering curriculum which prefigure writing as being what engineers are not expected to be 'good at', and not as important as technical skills, are so much a part of the 'unspoken narratives' of engineering educators that writing practices are marginalised. When they become part of what engineers do, they are re-framed as 'documentation'. This suggests that writing practices can be seen as intrinsic to engineering education and practice if or when they are re-framed as engineering practice.

Key Words: writing practices, engineering education, otherness, practice architectures theory

1. Introduction

1.1. Background

Engineering employers, engineering faculties and engineering educators expect that engineering students will automatically graduate with high level written and oral communication, yet these expectations continue to fall short, despite repeated calls by industry and by accrediting bodies such as Engineers Australia for engineering faculties to address this issue (see for example Goldsmith & Willey, 2015; King, 2008; RAE, 2007; Sheppard et al., 2009). A key reason for engineering graduates lacking strong communication skills is the engineering curriculum's focus on technical knowledge and a teaching approach which is predominantly knowledge transmission and reporting. The tension between what is emphasised in the engineering curriculum and what employers want is captured in the comment: 'employers ... increasingly emphasise not just technical expertise but call also for graduates with interpersonal and team-building skills, people who communicate well both orally and in writing, and people who respect differences in other cultures' (Walker, 2001, p. 78). One explanation for this ongoing shortfall is that the prevailing practices of engineering education constrain rather than enable the development of writing practices in the engineering curriculum, in part because writing practices are viewed as 'other', and as not belonging to engineering knowledge.

The research presented in this paper is part of a larger study examining the invisibility of writing practices in the engineering curriculum. In the study we argue that practices in the engineering curriculum cause writing practices to be both 'othered' and unsupported; the interaction of these practices thus render writing practices invisible to the majority of engineering educators and students.

This paper introduces the concept of 'otherness of writing practices in the engineering curriculum' and puts forward the idea that the prevailing identity of an engineer as a technical problem solver, in combination with the dominant practices of engineering education which identify with engineering as a hard applied science, construct writing practices as other and place them outside the frame of what is thinkable as engineering practice for engineering educators. One consequence of this is to constrain the development of students' writing practices. The lack of opportunities that engineering students have to practise writing does not provide the majority with the necessary communication skills to consult or negotiate with diverse stakeholders. The implications of this can be profound, as argued by Lee and Taylor (1996), who claim that contemporary engineering education produces engineering graduates who are compliant "servants of industry" in pursuit of technologies that "make things go faster, higher, longer" (p. 59). Thus they are ill-equipped to discuss whether such technologies are appropriate, or to debate concerns about the public good. A lack of ability to discuss the work that they do is seen as limiting engineers' potential to understand the social and political impact of their work (Johnston, Lee and McGregor 1995, p. 4). While not arguing that the development of writing practices in the engineering curriculum would necessarily transform engineering students into socially responsible actors, it can be seen that limiting the practice of writing discursively can also limit the range of engineering students' communication capabilities, and can construct a view that writing is not what engineers do. The following section explores the notion of the otherness of writing in the engineering curriculum.

1.2. The concept of Otherness

The perspective of the otherness of writing practices in the engineering curriculum is a somewhat novel one, and may not be immediately apparent until one begins to see a pattern: writing interventions that are introduced into the curriculum but not maintained beyond the initial push; howls of protest when engineering educators are expected to develop students' graduate attributes of communication; sayings (repeated in conversations in many different institutions) that: "it's not my job to teach writing" (Goldsmith & Willey 2016; Kranov 2009); calls for communication subjects external to the engineering science subjects to 'fix' student writing; regarding any subject

that develops written or spoken communication as 'soft'; and not wanting to be seen to be teaching a communication-type subject. This goes beyond marginalising writing practices, which happens elsewhere in the academy (e.g. Starke-Meyerring et al., 2014). In engineering, writing is repeatedly portrayed in images and in sayings as not what engineers do (e.g. Beer, 2002; Shapiro, 1991; Winsor, 1990). The 'otherness' of writing practices in the engineering curriculum may be an example of engineering educators maintaining normativity (Schatzki, 2012), where normativity in this context is the emphasis on the acquisition of propositional knowledge, referred to as 'knowing-what' – knowing about things (Biggs & Tang 2007, p. 73), to the exclusion of other types of knowledge.

Otherness (the Other, othering) is a concept that emerges in several fields of knowledge and illustrates the tendency of many societies to create a sense of identity through the construction of socio-cultural categories based on 'binary opposites' (Zavallos, 2011). The establishment of in-groups and out-groups depends on the dominant group having the power 'to impose the value of its…identity and to devalue the particularity of others (their otherness) …' (Staszak, 2008). The dominant group constructs anything that differs from the mainstream as 'other': minority cultural groups, speakers of minority languages, women – all have been constructed in various contexts as somehow outside the norm, and of being seen as different or strange. Engineering is typified as a masculine culture (Godfrey, 2009; Walker, 2001), involving "an ideal of manliness, characterised by the cultivation of bodily prowess and individual achievement" (Wajcman, 2010, p. 144). Given that the engineering identity centres on the primacy of technical knowledge (Hacker, cited in Wajcman, 1992; Trevelyan, 2010), writing practices may be cast as other in part because the image of an engineer writing conflicts with the idea of the engineer as a solitary, male, technical rationalist, tinkering with technology and communicating via calculus. To understand how the otherness of writing practices is realised in the engineering curriculum it is therefore useful to explore some ideas of engineering identity, in addition to considering how engineers view the knowledge of their discipline and the knowledge of writing practices.

1.3. Engineering identity

The definitions and narratives that engineering educators construct about engineering and about themselves both constrain and enable what it means to be an engineer. The prevailing view of engineers (both inside and outside the profession) is of technical problem-solvers (Sheppard, Macatanga, Colby, & Sullivan, 2009; Trevelyan, 2010) rather than as those who pose, frame and challenge the nature and type of problems. This is borne out by research conducted by Pawley (2009) on how engineering educators see the boundaries of engineering. Pawley identifies three ways that engineering educators define engineering: engineering as applied science and mathematics; engineering as problem-solving; and engineering as making things (2009, p. 312). She suggests that the current narratives of engineering reflect a backward-looking perspective and could be expanded to create a new image of "engineering as a creative, innovative, and inspirational field" (2009, p. 319): a change that is seen as desirable by external accrediting bodies but not necessarily by the bulk of engineering faculties.

Mathematics holds great significance in engineering, both as a language and as a way of circumscribing its territory. One reason for the lack of emphasis on the role of writing in engineering may stem from the belief that the language of engineering is mathematics. Several of Pawley's participants in her study express this belief: "'*But before you teach them science, you have to teach them the language of science—that's mathematics'*" (2009, p. 313), as do participants in this study (see section 3 in this paper). Godfrey and Parker (2010) make similar observations about engineering educators and students communicating with one another "using a very visual approach that linked knowledge transmission and communication by a mixture of diagrams, graphs, flow charts, and mathematics supported by, rather than built on, words" (p. 11). If it is accepted by most engineering educators that the language of engineering is mathematics, and only mathematics, there are major implications: one is that engineers and engineering educators can

use mathematics to communicate with others in their discipline, but not to people outside their discipline. Another implication is that the language of mathematics does not have the range of communicative functions that other languages have; as Godfrey and Parker (2010) accurately observe, it can be used for 'knowledge transmission' of mathematical ideas, but cannot be used for extended writing. This suggests that writing as a rhetorical act or as negotiating meaning may have limited relevance for those engineering educators who see mathematics as the main or only language of engineering.

"Math is more than a foundation or a language for some participants, it also is a defining marker, important in the drawing of boundaries around the engineering curriculum" (Pawley, 2009, p. 313). Mathematics impacts the formation of the engineering identity in a number of ways. The importance of mathematics as a subject which demands hard work and intense application to master is identified in Hacker's research into the connections between technology, engineering and desire (1989). As part of her investigation, Hacker enrolled as an engineering student to explore engineering education; she refers to the "role of discipline through mathematics and testing" (p. 56). The disciplining role of mathematics in engineering has been identified by several authors (e.g. Lee & Taylor, 1996; Faulkner & Herman, 2016). The degree of difficulty of engineering mathematics and the effort required to study it thus act as boundary markers for engineering, and as a means of weeding out those who cannot or will not submit to the discipline. They also act as boundary markers for what kind of knowledge is important for engineering, and by implication, what kinds of knowledge are less important. Studying advanced mathematics does not automatically preclude the development of writing practices, but the amount of time needed to develop 'fast, effortless algebra skills' (Faulkner & Herman, 2016, p. X) almost inevitably leaves little opportunity or room in the curriculum for developing writing practices. Whether accidentally or by design, writing practices are often seen as competing for the scarce resources of student and staff workloads, such as completing assessment tasks and marking them, respectively, and just as often losing that competition (e.g. Wheeler & McDonald, 2000; Goldsmith, Willey, & Boud, 2012).

1.5. Engineering and writing identity

As can be seen from the literature on engineering identities, the image of an engineer as someone who writes is generally in tension with the prevailing image or identity of an engineer as someone who does things, usually with numbers (Nagle, 1996; Pawley, 2009; Tonso, 2007; Winsor, 1990, 1996), and often by themselves. An insight into the view of writing that is held by many engineers can be found in the *Handbook for Preparing Engineering Documents*, written by an engineer for practising engineers:

> We tend to think about preparing documents as **writing**. And writing is, for many of us, a bummer. It's a quasi-clerical chore that we face when the real (that is, **engineering**) work is done. It reminds us of Miss Thistlebottom's 8th grade English class, in which we were bombarded with now-forgotten rules of grammar, and for which we got the lowest grade of our academic career. (Nagle, 1996, p. 6, emphasis in the original)

The above quotation encapsulates at least two key perspectives: that the real work of engineers is 'engineering', or "the engineering process" as outlined by Nagle – problem identification, design conception, design building, testing and production (1996, pp. 6-7); and that writing is synonymous with high school English, involving obscure grammar rules and in which engineers typically perform poorly: "and for which we got the lowest grade of our academic career". The prevailing practices of engineering hold this narrative in place – engineers are expected to be 'engineering', writing takes away from 'engineering', and whether or not engineers are capable of writing, they are not expected to be good at it. If engineers themselves say it, and keep saying it, even in a handbook for engineers on how to write, how can this narrative be disrupted?

Nagle argues that "we [engineers] are, in fact, doing something more than writing … we are doing something that is a surprisingly close analog to the engineering process" (1996, p. 6), and that preparing documents is more like "'information design' than writing reports" (ibid, p. 7). So the dominant view is that preparing documents is an engineering thing to do, while writing is 'a quasi-clerical chore'. Moreover, writing is linked in the minds of many to high school English, as demonstrated not only by Nagle in her light-hearted reference to Miss Thistlebottom (from Theodore Bernstein's *Miss Thistlebottom's Hobgoblins*), but also by several participants in this study, as discussed in Section 3 in this paper. If this is the dominant discourse about engineering and writing, it is not surprising that the majority of engineering educators see writing as not just outside their domain, but 'other'.

Probably the most detailed empirical studies of engineers and writing have been conducted by Dorothy Winsor (e.g. 1990; 1992; 1996; 2006). In her study of the writing that a practising engineer does, she notes that writing is viewed as part of an engineer's job, but not part of engineering (1990, p. 58). The tension between identity as researcher and as writer is also picked up by Latour and Woolgar (1986) in their anthropological study of scientific culture. They emphasise the omnipresence of writing for lab scientists, yet the members of the scientific laboratory were angry at being portrayed as participants in some literary activity (1986, p. 53). In both domains, the central role of writing to their practice is denied by engineering practitioners (Winsor, 1990) and by scientific researchers (Latour & Woolgar, 1986). Although engineers do not acknowledge or recognise the use of rhetoric in their writing because of the belief that engineering is about 'objectivity', Winsor (1996) argues that in fact "persuasiveness…is built into the very goal of engineering" (p. 11). Engineers believe that the presentation of facts does not need interpretation, and thus there is no need to persuade because the facts will speak for themselves. This is another illustration of how writing is 'othered': writing persuasively – particularly when it is called that – is not regarded as a legitimate engineering activity, but the 'preparation' of a report, or the 'documentation' of a process is seen as part of engineering work, albeit not a very exciting part (Nagle, 1996).

The engineering identity which thus emerges from the literature resembles Schon's (1983, p. 21) 'technical rationalist', the instrumental problem-solver rigorously applying scientific theory, mostly working in isolation and communicating to fellow engineers through diagrams and mathematical equations. It is not an identity which acknowledges engineers as social actors, although Trevelyan points out that social relationships are an essential component of engineering practice (2009, p. 6). This engineering identity – filtered through the lens of engineering educators – does not provide space for writing as a practice, for writing to negotiate meaning, to argue, discuss, question or justify. Overall, the literature presents an engineering identity that does not provide room for engineers or engineering educators to see themselves as authors, nor does there seem to be scope for an institution-identity (Gee, 1999) that practises writing, despite the writing practices that are an everyday element of their practices. The next section discusses the predominant view that engineering science represents engineering knowledge in the engineering curriculum, and how this impacts the perception of writing practices within the curriculum.

1.6. The engineering curriculum as engineering science

The current engineering curriculum in Australia (and predominantly in the US) is based on the engineering science approach, which valorises convergent thinking (Dym, Agogino, Eris, Frey, & Leifer, 2005) and "emphasizes the scientific and mathematical foundations of engineering, as opposed to empirical design methods based on experience and practice" (Wulf & Fisher, 2002). Part of the emphasis on engineering science is tied in with the perception of the need for 'rigour' in the engineering curriculum. The engineering educators who teach the engineering science subjects, such as thermodynamics, fluid mechanics and solid mechanics (Lucena, 2003, p. 421) often regard themselves as the guardians of the standards of engineering, hence the importance of the 'weeding out' culture. They must protect engineering standards by making sure that the assessment of their subjects is rigorous, such as examinations that test individual acquisition of

knowledge through the solving of equations, multiple choice answers or reproducing correct formulae, rather than through group work where students can 'cheat', or written responses that ask for evaluations, judgements, or applying solutions outside of textbook problems (Goldsmith, Reidsema, Beck, & Campbell, 2010). The engineering science curriculum places high value on accuracy and speed of calculations, of excellence in problem-solving and command of technical knowledge, but it places much less value on developing the professional attributes that students are assumed to be graduating with, such as oral and written communication skills, which are more time-consuming to develop and assess. One reason for constraining the practice of writing in the engineering curriculum is the perception that there is no 'room' for writing; as previously noted, it competes for the scarce resources of teaching and marking time with the propositional knowledge which is highly valued and which can be measured by tests, quizzes and final exams. Although an extended written response to an exam question may be able to demonstrate depth of understanding and analysis, writing is more difficult to evaluate and takes longer to mark than solutions with only one possible correct answer (Wheeler & McDonald, 2000).

Furthermore, writing practices are less valued in the engineering curriculum because writing is a different kind of knowledge. It is 'other'. Many engineering educators regard writing as an activity which is practised by practitioners of other kinds of knowledge, such as those in the humanities and social sciences. The classification of types of knowledge is explored in legitimation code theory (LCT), which is based on the knowledge codes developed by Bernstein (e.g. 2000). Maton and colleagues (e.g. Maton, 2000, 2010; Muller 2009; Winberg, 2012; Wolff & Hoffman, 2013) have expanded the idea of knowledge codes to classify knowledge with increasing subtlety. In LCT, different ways of knowing are classified and placed on continua of knowledge codes and knower codes based on the strength of their *epistemic relations* and their *social relations*. LCT is an evolving field, but at the time of writing there are four main classifications of knowledge structures, two of which are relevant to this discussion: knowledge codes and knower codes. A *knowledge code* is defined as having strong epistemic relations: knowledge is built in a hierarchical structure that needs to be followed, so that foundational knowledge needs to be learned before acquiring more complex knowledge. A knowledge code also has relatively weak *social relations:* it is not who you are but what you know (Maton, 2010). In contrast, a knower code has relatively weak epistemic relations with a horizontal knowledge structure, but strong social relations: the knower (a specific cultural or social group) has a particular gaze (Maton, 2010) that provides a unique insight. Engineering is classified by several authors (e.g. Geirsdottir, 2011; Muller, 2009; Wolff & Hoffman, 2014; Wolff & Luckett, 2013) as a knowledge code, with a hierarchical knowledge structure (Geirsdottir, 2011). There is less literature that classifies writing or writing practices as a type of knowledge, but secondary school English is regarded as predominantly a knower code (Martin & Maton, 2013; Jackson, 2016). The connection in engineers' minds between writing and secondary school English is illustrated in the quotation from Nagle (1996), and is also made by participants in this research, as discussed in more detail in section 3 of this paper. This suggests that many engineering educators see writing practices as akin to the study of English – a different kind of knowledge from engineering – and so do not perceive that writing 'belongs' to engineering.

This perception aligns with the discourse of the engineering curriculum which speaks of hard skills versus soft skills. The association of writing with softness occurs within this discourse (Colman & Willmot, 2016; Johnston & McGregor, 2004), and casts soft skills as 'skills, which are somehow easy, light, and not to be taken seriously' (Johnston & McGregor, 2004, p. 71). Colman and Willmot observe that "less merit is attached to soft skill competence and hence they are often perceived as easier than 'hard' skills'" (2016, p. 4). Another reason for the resistance of the engineering science gatekeepers to include writing in engineering may be the desire to keep engineering 'hard', unsullied by association with something as 'soft' as writing practices. The juxtaposition of hard and soft types of knowledge is commented on by Hacker in her study: 'Some fields of engineering – notably electrical and computer science – had more prestige than others. Their

activities and skills were clean, hard and fast … The social sciences … were described in terms similar to those used for women – soft, fuzzy, "noise", unpredictable, unscientific' (1989, p. 35). The association of the hard skills with masculinity has been made by several authors (e.g. Lee & Taylor, 1996; Wajcman, 2010); both Hacker (1989) and Walker (2001) make the connection between soft skills and feminine qualities. Although a discussion of the gendered nature of engineering is beyond the scope of this study, it is difficult to overlook the connection between communication as a 'soft skill' being associated with more feminine qualities and the belief that 'being good at writing' equates to being somehow feminine, which certainly conflicts with the dominant engineering identity, and with the type of knowledge that is highly valued in the engineering curriculum.

It can thus be seen how the prevailing engineering identity, associated with masculine qualities and technical competence, interacts with the valorisation of engineering science to render writing practices as other in the engineering curriculum. The following section outlines the approaches taken to the study, including a brief explanation of practice architectures theory.

2. Methodology and methods

The exploration of the otherness of writing in the engineering curriculum is part of a study of the invisibility of writing practices in the Australian engineering curriculum, investigating the underresearched perspectives of engineering educators on writing (but see Jenkins et al., 1993; Zhu, 2004). The study uses practice architectures theory as both a theoretical perspective and a methodological lens. Practice architectures theory (PAT) (e.g. Kemmis & Mutton, 2012) has evolved from Schatzki's practice theory (e.g. Schatzki, 2012), where the focus is on the site of practice, how the practice is conducted, its temporal and physical location, and the arrangements that hold it in place. PAT can allow investigators to see not only what is happening in a practice, but how this has come to be and why certain practices become 'the way we do things around here'. In keeping with Schatzki's understanding of the localised nature of practices, PAT is used to analyse a site of practice; a site of practice is 'that realm or set of phenomena of which it is a part' (Schatzki, 2003, cited in Mahon, Kemmis, Francisco, & Lloyd, 2017, p. 9). In addition to providing a lens to analyse practices and what lies behind them, PAT also provides the language to discuss the complex interplay of forces that create conditions in which certain types of learning are constrained and other types of learning are enabled. It does this by identifying three different kinds of arrangements that exist simultaneously in a site of practice, and which hold those practices in place: cultural-discursive arrangements, material-economic arrangements and social-political arrangements. Cultural-discursive arrangements are resources that prefigure what can be said and thought about a practice (the sayings); material-economic arrangements include aspects of the physical environment, financial resources, and divisions of labour that shape the doings of a practice; social-political arrangements incorporate organisational functions, rules and roles that shape the relationships (relatings) amongst participants and non-human objects in a practice (Kemmis et al., 2014). It is important to note that the arrangements should not be considered or analysed separately; they interact with one another to prefigure (but not predetermine) the happenings of a site of practice. For example, what is thought and said about writing in the engineering curriculum (cultural-discursive arrangements) interacts with how writing is developed and assessed in engineering subjects (material-economic arrangements), and both of these practice architectures interact with how engineering educators relate to their students as practitioners of engineering writing (social-political arrangements). Working in concert, these arrangements thus both enable certain teaching and learning practices of writing in engineering, and constrain others.

The research explores engineering educators' perspectives of writing in the Australian engineering curriculum; thus the focus is on the practices of engineering educators, the subjects they coordinate, and the writing practices that are part of their subject. Engineering academics who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities were invited to participate in the study; subject coordinators were targeted as they

have a certain amount of control over the teaching and assessment of their subject. Nine participants were recruited from five institutions in three capital cities; all the participants teach technical subjects from a wide range of engineering disciplines. The participants were asked to provide relevant documents such as subject outlines, support documents and samples of student assignments if available. Published writing by the participants (available in the public domain) was also included. The documents were analysed and the participants were then interviewed using semi-structured questions to investigate how they view their students' writing practices, their own writing practices as engineers, and the writing practices of the engineering curriculum. Some participants consented to be observed when they were teaching; notes from these classroom observations were analysed as part of the data. The interviews have been transcribed and analysed to identify key themes, using Concordance (Watt, 2011). The themes and other data are examined through the lens of practice architecture theory (PAT), using the local site of practices of the participant as the unit of analysis. The interactions within the subject are the unit of analysis and are termed the site of practice (Mahon et al., 2017, p. 9): what the engineering academics say and do in their teaching; how they relate to their students; and what the students are required to do in these subjects. In line with ethical considerations, all participants and their institutions have been de-identified and given pseudonyms to preserve confidentiality. In addition, details of specific subjects taught have not been included.

3. Findings and Discussion

3.1. The practices of othering writing

The practice architectures of the engineering curriculum interact with the sayings, doings and relatings of the participants to hold in place practices which render writing practices as other. The practices of the construction of the engineering identity as a technical problem solver, the relationship of mathematics to engineering studies, the valorising of engineering science, and the language used to refer to writing practices as a soft skill all work together to make writing practices strange, so that they are not perceived as belonging in the engineering curriculum. The following sections discuss othering practices that have emerged from the analysis of the sites of practice, and which are mainly found in the sayings of the participants, but can also be seen in their doings and relatings. However, as the practitioners themselves are possibly unaware of how their practices could be seen as othering, it is not always easy to ascertain why these practices may have arisen.

3.2. Othering practices in the sites of practice

One facet of the otherness of writing practices which relates to the engineering identity is the emotional dimension, or the affective domain, that writing practices occupies for some of the participants, and which emerges in the emotive language of their sayings when they talk about writing and writing practices. This language is used both to talk about their students' writing practices and the participant's own writing practices as engineers: all but one participant (Charlie is the exception) have several publications, as is expected of university educators. The emotional dimension that writing inhabits is an indicator both of writing as a different kind of knowledge from the propositional knowledge of engineering science and of the association of writing practices with 'soft skills'. This association is specifically referred to in the subject documentation for one participant's subject, where he distinguishes between cognitive skills such as technical abilities, and 'non-cognitive skills...also referred to as soft skills [which] include...communication abilities' (Charlie's learning guide 2014, p. 11). Some of these affect terms have been identified in Table 1, and are contrasted with the affectless terms used by the participants to describe the propositional knowledge in their engineering subjects.

Table 1. Affect terms about writing and about propositional knowledge.*

Participant	Affect terms about writing	language about propositional knowledge
Adam	Horror stories, poor, worse	Basic understanding; plugging and chugging
Charlie	Abysmal, annoyance, beautiful, beautifully, beautify, boring, embarrassing, enjoyed, fear, Hallelujah, happy (not happy), joy, nice, poor, screaming, wonderful	simply
Eric	Difficult, terrible, worst	Fundamental, basic, basically
Garth	Disappointing	solely just math, equation and numbers
Harry	almost impossible	very abstract, very mathematical
Ivan	Appreciate, attitude, bad, best, confidence, confident, crazy, depressing, depressingly, dreadful, dreadfully, embarrassing, enjoy, feeling, feels, felt, frustrating, hated, hopeless, horrified, jaundiced, like, love, nuisance, pleasant, pleasure, poor, serious, surprising, suspect, suspicious, torn, trusted, valuable, woeful, worried, worry, worrying	very simple, technical (errors, issues, stuff), basic, basically, calculation (errors), just sums, stuff

*Three participants (Bernice, Damien and Felicity) did not use affect language when talking about writing.

As can be seen from this table, the affect terms mainly express disappointment, with a sprinkling of joy. Charlie, Eric, Garth and Harry all express a range of emotions about writing, but the most striking example is that of Ivan's language: it is strongly in the affective domain, and is in contrast to his sayings about the propositional knowledge that his students are expected to acquire and to demonstrate in the tests and final exam. The participants' sayings about student writing frequently express anguish:

> Some of them [student reports] were really abysmal. (Charlie)
>
> Sometimes it's quite disappointing, I mean how can a fourth year undergraduate student write an email like this? (Garth)
>
> … I was horrified. How can they write like this? You can't read it, it's just dreadful. (Ivan)

In some sites of practice (Charlie, Eric, and Harry), the participants' sayings interact with their doings and relatings by providing opportunities for formative or summative feedback on how to improve the 'dreadful, abysmal, terrible' writing, but in the sites of Adam, Garth and Ivan, the sayings are private hand-wringing with no feedback loop. The distress expressed by the participants about their students' lack of proficiency in writing practices is evident: several comments refer to the unreadability of the students' writing. There is also a noticeable commonality in the comments from the participants about the poor performance of students in writing tasks and the belief that those students (or most students) have not taken the task seriously (Charlie, Eric, Garth, Ivan). However, the consequences of the students' poor writing practices are less detectable: the majority of the participants said they would not fail a student on the quality of their writing, but they would fail a student who did not demonstrate adequate knowledge of the subject content.

The comparison between talking about writing and talking about propositional knowledge is noticeable:

> [the assignment] is just solely just math, equation and numbers, that's all. (Garth)
>
> Then they fill in a, basically a template during the lab where they do the calculations and have to answer some simple questions … the exam is totally the technical stuff. (Ivan)

The propositional knowledge is described as abstract, basic, simple, technical, and mainly mathematical; equations that need to be learned, formulas and algorithms to be written and applied. Above all, it is knowable and either right or wrong. If students do not do well in the subject, the subject coordinators comment that it is because they probably haven't attended classes or done their homework. The (possibly unintentional) message conveyed by the different attitudes towards the quality of students' written work as opposed to the accuracy of their technical knowledge is that students can pass engineering subjects with poor quality writing. Thus it is quite possible that students will continue not to take writing seriously, until their final year honours thesis or capstone project, when writing suddenly becomes very visible and very serious. In fourth year, the practice architectures of the engineering curriculum shift: the focus is on the production of a written artefact of substantial length. The honours thesis or capstone report can be 50-100 pages, or 20,000 to 40,000 words and is expected to demonstrate the student's research skills, including a command of research literature. It could be argued that the need for students to produce such a lengthy document shows that writing is part of the engineering curriculum, until one realises that students are required to write the thesis or capstone report with little, if any, prior experience in extended writing or in research writing or reading. In this light, the otherness of writing becomes more noticeable – it is a skill, to be 'magicked up' on the rare occasions it is needed – not a practice that has to be learned and developed.

This analysis brings to light two key points. The first is the contrast between the emotion-laden sayings about writing practices compared to the descriptions of propositional knowledge in these participants' sites of practice, where the language is either affectless or uses terms such as 'simple', 'basic', 'just (technical) stuff'. Comments about students' lack of propositional knowledge indicate that at least some of the participants expect their students to struggle: '*Not many of them get it*' (Adam); '*– I just know that they won't get full marks because no-one can do that*' (Ivan), underlining the engineer identity, anchored in the effort to acquire difficult technical knowledge, which is also 'basic' for those participants – suggesting that they may have forgotten how hard it was to learn, or that such knowledge came easily to them. Yet the emotional dimension is absent; for these participants the acquisition of propositional knowledge is cognitive, not affective. The participants' sayings interact with their doings and relatings – the values they ascribe to types of knowledge and which their students will pick up on, consciously or subconsciously. These are elements of the practice that cast writing as a 'soft' skill, and which intentionally or not assign writing to the emotional domain – the realm of the feminine, as noted earlier.

Another key point is the participants' sayings about their own development of writing practices, which demonstrate both emotion and the struggle that writing can involve:

> There were times in my life where writing was just almost impossible. (Harry)
>
> ... because actually I hated writing. (Ivan)
>
> for me ... the worst case – the most difficult part is for the writing. (Eric)
>
> I think for them it's quite disappointing in my first few reports. (Garth)
>
> I'm never happy with what I write. (Charlie)

Here the participants reveal how hard writing as a practice can be, (difficult, almost impossible) as well as its affective domain for them (worst case, disappointing, hate, never happy). This may relate to how writing is not something that is expected to come naturally to an engineer, or that writing puts them out of their comfort zone. The discomfort might be due to a lack of confidence with their knowledge of writing, or because writing never has one right answer. It could also be

that at some level they recognise that the practice of writing – this 'soft' skill - is in its way as hard as the 'hard knowledge' of engineering. Yet the time and effort required for engineering students to develop strong writing practices is acknowledged only infrequently, perpetuating the perspective of writing as somehow extraneous to the learning needed to become an engineer.

An analysis of Ivan's site of practice as a focal point can illustrate most clearly how the emotional dimension of writing plays out in the practice architectures of his site, and his ambivalent attitude to writing practices as compared to propositional knowledge, both for himself and for his students. Students in his subject are required to write a two-page report based on their laboratory sessions. The level of distress that Ivan expresses about the poor quality of the reports is greater than his distress over students' poor performance in the subject overall: '*…then I read the first sentence of their introduction and I'm going oh no, oh no. This is not going to be happy'* (Ivan interview). However, the report is worth 10%, while the quizzes and the final exam combined are worth 72%. Ivan can see that the low weighting of the report compared to the quizzes and exams means that a substantial number of students put less effort into writing the report than into other assessment tasks:

> … so one of the feedbacks, so why they don't do better at the lab report was well it's only worth eight per cent [sic] of the mark. Well if I made it 20 per cent would you do a better job? I think they would. (Ivan interview)

Yet he does not increase the weighting, commenting that he wants the students to focus on "the technical stuff", although later in the interview he remarks that what the students learn (or can learn) from the analysis required in the report is "really, really valuable". His conflicted attitude to the role of writing in his subject recurs throughout the interview. He calls himself 'crazy' for requiring his students to write a report, commenting both that he has to give the students 'a lot of guidance' and that he does not give them much: possibly he means that the students need a greater level of guidance than he is prepared to give. He expresses distress and ambivalence when he explains the task that the students need to do; on the one hand he comments that the students do not know how to write an argument:

> … I have to give them a lot of guidance about how to do it. I don't say I give them a lot, I show them an example from previous years and I talk about what's required. But they've just got no idea about how to present sort of an argument. (Ivan interview)

On the other hand, he claims that what he is asking them to do is 'just simple stuff', although he comments that it is a novel experience for them and extremely valuable. At the same time, it is a summative assessment. The teaching and assessment practices in his site of practice constrain opportunities for students to practise writing, to see the value of learning such writing practices, or to receive feedback, as evidenced by his response:

> … So I mean I see that as really, really valuable but I'm not sure how the students see it because it comes at the end of semester. By the time I've marked it I never really get the feedback as to the value they see in it. (Ivan interview)

Ivan says that he does not get feedback from students about the value of the task, or of the practice that they get in presenting an argument. Students also do not get feedback on their work until it is too late for that semester, and perhaps not even then. The practice architectures and elements of practice interact in Ivan's site to convey the message that writing practices are not to be taken as seriously as the important, technical knowledge of the subject. Although he recognises writing as important, providing opportunities to practise writing without assessment does not fit within Ivan's subject. The conflicts that emerge from his site of practice suggest that for him, writing occupies a very different territory from that of propositional knowledge.

3.3. Writing practices that have many names

The following sections explore some of the different meanings and interpretations of writing practices that have emerged from the data analysis, and how writing practices are constructed as a different kind of knowledge in the sites of practice.

Writing practices can be seen to be another kind of knowledge in the participants' sites of practice by the way they are spoken of in the interviews, written about in the subject and assessment documents, and commented on in assessment tasks. The most striking incidence is the frequency with which several participants use 'English' interchangeably with writing/writing practices in their interviews. English is used 73 times by the participants. It is never used by the interviewer, who refers to writing and writing practices, but the majority of the participants refer to English, and English has many meanings. These have been summarised in table 4.2, along with interview extracts to provide some context for the comments. English can mean: English language proficiency; English as a second language (ESL); good (or poor) written expression; English as the language that one writes in (as compared to the language of mathematics); correct or appropriate grammar; or English as a secondary school subject. These responses bring to mind the quotation from Nagle (1996) regarding engineers' responses to writing: at least for Harry and Ivan it reminds them of high school English; Ivan remembers hating English in secondary school and not doing well in it, whereas Harry describes himself as moderately okay at writing because he had a very good English teacher. Such diverse understandings form part of the practice architectures which prefigure writing practices being seen as other in the engineering curriculum. If engineering educators conflate writing practices with English, it contributes to an explanation of why they resist practising or developing writing in their subjects. They are teachers of engineering, not teachers of grammar, of ESL or of literary criticism.

Table 2. What English means.

Participant*	**English as …**	**context**
Adam	the typical comments will be you need to work on your English because this has not been – very poorly expressed	English as written expression
Bernice	if English is not their first language they may lack confidence	English as a language (ESL engineering educators)
Charlie	We're using mathematics as a – it's a language – no different from English	English as a means of communication
Damien	Having poor basic English expression …	ESL students
Eric	Sometimes I write even in Chinese first and then translate it to English	English as a language
Harry	I had a really good English teacher in high school	English as a secondary school subject
Ivan	getting them to write it in English, appropriate grammar, language and all that;	English as correct grammar;
	this is very interesting because I hated English at school	English as a secondary school subject

*Two participants, Felicity and Garth, did not use the term 'English'.

Beyond the conflation of writing practices and English, there is considerable slippage of terms used by the participants about writing practices, such as: *communication; critically analyse; demonstrate understanding; discussion; grammar; presenting information; reporting; written expression*. The diversity of terms for writing practices (the sayings) can be seen in the wording of assessment tasks (the cultural-discursive arrangements) and of criteria for assessing written assignments – the material-economic arrangements and social-political arrangements – reflecting a lack of clarity about the role and nature of writing practices in the participants' subjects. In some (but not all) sites of practice in this study, it is not always clear from the subject and assessment documents what level or type of writing is expected of the students, nor where the students should be focusing their efforts: is it more important to describe the methods, explain the calculations, or justify the approach? The range of terms used about writing practices can lead to unclear wording and requirements of learning outcomes and assessment tasks, which in turn can cause students to become confused and frustrated.

This slippage is not unique to engineering educators; many disciplinary academics lack familiarity with the language of disciplinary literacy, as remarked on by several authors (e.g. Fischer, 2015; Hasan, 1999, Lea & Street, 1998; Lillis 2006). Halliday and Martin (1993) comment on the paucity of resources amongst academics to discuss language: 'linguists often notice how when highly sophisticated thinkers from other sciences turn their attention to language they ignore the findings from linguistics and regress to treating language at the level at which it is presented in the early years of secondary school …' (1993, p. 17). This comment reflects both Nagle's representation of what writing means to engineers (1996) and the views of the majority of participants in this study, who are probably still working from models of language that have not developed since they themselves were in secondary school. An underdeveloped model of language means that engineering educators may not be able to explain adequately what is required in a written task, or where students are making mistakes; they lack the meta-language to articulate their expectations. As Fischer (2015) reports from her study of working with tutors and postgraduate engineering students: 'Subject specialist and teachers often "know" what they are expecting students to produce but: a) they are not used to articulating such discursive knowledge; b) it may be that it is far from clear what the nature of the knowledge expected is…' (p. 83).

Several participants in this study lack the meta-language to explain what is expected of the students both in their writing development and in the assessment tasks. For example, Adam teaches a later year subject delivered in block mode, comprising three intensive teaching periods over the semester. The description of the first assignment does not include the type of text that the students should be writing, (the description does not use the word 'report'), length of answer or weighting of any of the parts; there is no information about assessment criteria. As in Fischer's (2015) study, Adam 'knows' what he expects the students to produce, but the students must have to use considerable guesswork to decide how to write this assignment, and the two that follow on from this one. It is not until the third assignment that the assessment description uses the word 'report'.

Another example of the lack of meta-language can be seen in the following comments from Ivan, when he is describing the misconceptions that his students have about what and how he is asking them to write. He tells them that they are supposed to be writing a story – "a narrative" – but is concerned when they submit writing that is in his eyes 'flowery' and inappropriate. The examples thus far reveal the gaps in knowledge or awareness that the participants have about the writing practices they require of their students. Their practices do not always provide students with the necessary information to complete the tasks, or they do not have the meta-language to explain how students might improve their writing. Engineers pride themselves on their accuracy of calculations and the high priority placed on risk management, but this attitude does not stretch to their approach to the use of language.

3.4. Practices that do not 'other' writing

Thus far we have discussed practices that other writing in the engineering curriculum. However, there are practices that do not other writing; these practices incorporate writing practices as part of students' learning of the propositional knowledge of the subject. These include the teaching practices, the assessment practices and the sayings, doings and relatings of the participants which normalise writing as part of acquiring engineering knowledge. The sites of practice where the inclusive practices are most in evidence are those of Bernice, Damien and Harry, although other sites of practice also have some of these practices. Bernice and Harry teach first year subjects while Damien teaches a second year subject; they are from different universities and different engineering disciplines. Teaching practices that provide opportunities for students to practise their writing as part of their learning can be seen in Bernice's interactive tutorials, where students are encouraged to work in groups to solve problems and present the solutions to the whole class. Damien's students have a lecture where they are introduced to an online resource to support their report writing (the WRiSE site, 2012); in Harry's subject, students are required to keep a record of their tutorial and lab work in a laboratory notebook, which is assessed as satisfactory or unsatisfactory. All three participants scaffold writing practices by providing models of assignments, either dummied up or from previous years, and formative and summative feedback on written assignments. Assessment practices which frame writing as a practice are in evidence in Harry's and Damien's sites: students write preliminary reports which are given formative feedback; this feedback is then expected to be used in the final (summatively assessed) report. In Bernice's site of practice, students are specifically directed to incorporate the feedback from their first report into their second and more complex report. The subject documentation in all three sites of practice has concise and explicit information about marking criteria for written assignments, including the type of text, the structure and the expected number of pages. In their interviews, all three participants refer to developing their students as professional engineers over a four-year program; this contrasts with the sayings of some of the other participants, who comment on the learning that students acquire in their subjects, but not on the learning that occurs prior to or following their subjects.

When the practices of Bernice, Damien and Harry are compared with those of other participants, several notable differences can be observed; the first is their sayings, supported by the doings and relatings of their sites of practice, that writing is a practice which needs to be developed, rather than a skill (although Damien frequently refers to 'report writing skills' he also comments on the developmental nature of report writing). Another difference their belief that writing consolidates learning, as these interview comments demonstrate: *practising using that language I think helps with understanding the concepts* (Bernice); *the minimum amount [required] is basically is to reflect on the information that's already been provided to them* (Damien); *we ask them to write reports so they actually engage with it [learning]* (Harry). The participants see that writing (and speaking) can help students to clarify the concepts, reflect on what they have learned and engage with their learning. A third difference is their understanding of their role as engineering educators to develop their students' professional engineering identity. The participants explicitly talk about preparing their students to become engineers partly through developing their writing; for Bernice it is about developing a professional identity. Damien comments that if engineering graduates have poor report writing skills "it's going to reflect on your success in the organisation", while Harry sees the development of students' writing in engineering as developing their critical evaluation capabilities, which prepares them for "their life as an engineer". Each site of practice is unique, and has local conditions that enable and constrain certain teaching and learning practices, but the analysis demonstrates how the practice architectures and practices in these three sites interrelate to make writing practices part of learning to become an engineer.

4. Conclusion

In this paper we have argued that writing is othered in the engineering curriculum, partly through the construction of the engineering identity as a solitary technical problem-solver, and partly through the view that writing is a different kind of knowledge from engineering knowledge. The study has identified practices where writing is othered in the engineering curriculum in the sites of the participants, but has also identified practices that include writing as part of learning to become an engineer.

The findings provide an understanding as to why, despite decades of interventions to develop writing in engineering (e.g. Carter, Ferzli, & Wiebe, 2007; Fischer, 2015; Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999; Lord, 2009; Mort & Drury, 2012; Pflueger, Weissbach, & Gallagher, 2015), writing practices keep disappearing from the engineering curriculum, and why there is continued resistance by engineering educators to incorporate writing practices into their subjects. In particular, the conflation of writing with 'English' (and the range of meanings that English has for the participants), would explain why many engineering educators choose not to provide explicit instruction about writing practices in their teaching practices; they do not see themselves as teachers of English nor as writing practitioners. The lack of meta-language to explain what is required in a written assignment, or to provide feedback on students' written work, can lead to confusion and frustration. This is another reason for othering writing practices: if it becomes too hard to convey what is expected, engineering educators might remove writing tasks altogether from their subjects, and ask that 'communication' be taught elsewhere.

The examples of practices that integrate writing practices into the learning practices of the students, thus 'normalising' writing as part of engineering studies are intriguing; the participants are from three different institutions, teach in three different engineering disciplines, and have slightly different intended learning outcomes. Yet all three have sought to develop their students as professional engineers with strong writing practices. The implications of these findings for engineering faculties suggest that if writing practices are to be seen as part of engineering practice, more work needs to be done to develop an understanding that writing is a practice, and that these practices need to be developed consistently throughout a degree program. The notion of 'practising writing', rather than 'teaching English' also needs to be unpacked, and the importance of a shared meta-language about writing practices is not to be discounted. We are not suggesting it is possible to change the dominant engineering identity, but is it possible to change the identity of writing practices, so that they can be seen as part of learning to become, and learning to practise, as an engineer?

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