Investigating the Invisibility of Writing Practices in the Engineering Curriculum

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Certificate of Authorship/Originality

I, Rosalie Goldsmith, certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student:

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Date: 28 May 2018

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Dedication

To my parents, Audrey and Lindsay Goldsmith, who taught me to value education, and who would have been so proud.

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List of Abbreviations

ABET	Accreditation Board for Engineering and Technology, Inc.
ADTL	Associate Dean Teaching and Learning
ALL	Academic language and learning
AT	Activity Theory
DEC	Design of Electronic Circuits
DEEWR	Department of Education, Employment and Workplace Relations (Australia)
EA	Engineers Australia
EAL	English as an additional language
ESL	English as a second language
PAT	Practice architectures theory

List of Terms

ALL lecturer	Academic/professional staff who develop students' disciplinary literacies
Associate Dean Teaching and Learning	provides strategic leadership in teaching and learning in a faculty
Engineering educator	Academic staff teaching engineering in a university
Engineering program	Course of study which leads to an engineering degree
Engineering subject	Unit of study as part of an engineering degree program
Graduate Certificate in Higher Education	course of study to introduce principles of learning and teaching for university educators
Subject coordinator	Responsible for the design and delivery of a unit of study

Abstract

Engineers are expected to have high level communication skills in order to carry out their work, which includes interacting with diverse stakeholders, colleagues, employees and clients. Of particular importance is the ability to negotiate, evaluate, persuade and make recommendations, both in speaking and in writing.

However, it is difficult to see where writing practices are developed in engineering degree programs. Specifically, the gap between writing practices in the engineering curriculum and those of engineering practice has been acknowledged for decades by employers and by organisations such as Engineers Australia, but the continuing emphasis on engineering science in the Australian engineering curriculum provides little room for the development of writing practices which negotiate meaning and which provide opportunities to develop critical analysis and evaluation. Writing practices can be said to be invisible.

This study investigates the contributing factors to the invisibility of writing practices in the engineering curriculum, looking at how writing practices are made invisible. A practice theory perspective was used to inform the research questions and to analyse the data collected from the case studies of nine engineering educators from five different Australian institutions and a range of engineering disciplines.

The study found that there was a range of practices across the case studies, but that the majority of practices in the participants' sites of practice constrained rather than enabled the development of writing practices in the context of learning engineering knowledge. Some of the practice architectures which held the constraining practices in place were at the local level, while others appeared to be part of institutional practices. However, some case studies had practice architectures which held in place practices to enable the development of students' writing, within a subject, across sequential subjects or throughout an engineering discipline. These case studies provided evidence of the arrangements which prefigure supported writing practices in the engineering curriculum. The significance of this research is to provide empirical evidence of the constraints around writing practices in the engineering curriculum which have been acknowledged anecdotally for some time. Further, the study shows

how writing practices can be supported, given the appropriate practice architectures, and provides a language with which to talk about these arrangements.

Chapter 1
Introducing the Invisibility of Writing Practices in the Engineering Curriculum

Prologue

When I'm asked what my PhD is about, and I tell people 'investigating the invisibility of writing practices in the engineering curriculum', I receive comments along the following lines: 'Good luck!'; 'Well, there's a lot of scope!'; 'But engineers can't write'. In addition, in conversations with colleagues, some engineering educators will say that they're not good at writing; others will say that engineering students and educators aren't good at writing. Yet engineering practice places great demands on writing, and indeed many engineers are highly proficient writers. The perception of the 'non-writing engineer' is an assumption that has significant impacts for the engineering curriculum and for engineering practice.

Introduction

1.1 Background

Engineering practice requires engineers who are able to create, innovate, collaborate, coordinate and communicate. Engineering is not a solitary pursuit; it is multidisciplinary, relying on the complex reality of working in teams to build on ideas, design and decompose problems, evaluate strategies and optimise solutions. Engineers therefore need to reason, argue, explain, discuss, negotiate, recommend, justify and evaluate. These activities can take place using verbal communication, but are more usually enacted through writing. Writing in engineering encompasses a wide range of practices, from notation and sketching to critical analysis and evaluation. These practices are discussed further in Chapter 2; for now, it suffices to say that writing practices are an intrinsic part of engineering practice (e.g. Leydens 2008; Missingham 2006; Trevelyan 2010; Winsor 1990, 1992).

Writing practices are a means of explaining to oneself, to others and to society the relevance of research, ideas, problems and possible solutions. Writing practices are a way of discussing and communicating innovations. Writing practices are a means of exploring, harnessing and conveying creativity. Writing practices are important as a part of research, as a way of learning, as a way of working through complex ideas and as a way of clarifying one's thinking.

However, it is difficult to see the development of writing practices in the engineering curriculum. Writing practices may exist, but may not be seen as such by students and staff; they may exist but may not be developed; they may exist but be in the form of notation rather than of extended writing which involves the language of negotiation. The gap between writing practices in the engineering curriculum and those of engineering practice has been identified in studies and reviews of engineering education for several decades (e.g. Appleby et al. 2012; King 2008; Lloyd et al. 2001; Male, Bush & Chapman 2011; Mort & Drury 2012; Mort et al. 2012; Trevelyan 2009, 2010), but writing practices continue to be invisible in the engineering curriculum – they are frequently invisible to students, they are frequently invisible to engineering educators, and they are frequently invisible to engineering faculties. The term 'invisible writing practices' is employed in this study to convey a range of meanings – to refer to (often excellent) writing practices that exist but only in isolated contexts; that exist but are separate from the engineering curriculum; that exist but are not acknowledged; that once existed but have fallen into disuse; that should be practised but are ignored or regarded as someone else's responsibility; and to refer to writing practices that are missing.

Many people have worked tirelessly for decades to develop engineering students' written and spoken capabilities, yet the traces of that work can be almost impossible to detect in engineering studies. While it is highly likely that such work – for example, lectures delivered by engineering educators on the importance of written communication, targeted workshops on report writing or on giving group or individual presentations, academic language and learning (ALL) lecturers co-teaching with engineering educators, context-specific teaching resources to support writing and speaking, subject design to incorporate writing in the content areas – has benefited the students and the engineering educators who have been involved in these initiatives, there is little sustained impact on the engineering curriculum.

When I started working with engineering educators to help develop their students' written and spoken communication, it quite quickly became obvious the resistance with which these developments were met by engineering students (e.g. Gardner, Goldsmith & Vessalas 2016; Mort et al. 2012; Skinner et al. 2012) and by many staff (e.g. Goldsmith & Willey 2016b; Kranov 2009). When I started doing a literature search on written communication in engineering, it also became obvious how many initiatives had been implemented over the years in different countries, and how many had fallen into disuse after the immediate problem was seen to be resolved or the initiator had moved on.

What is it about the engineering curriculum, and about writing practices within this curriculum, that causes writing practices to disappear, to be the first thing to be scrapped when the number of students increases, or the weeks of a semester are shortened, or the subject coordinator changes, or there are cuts to the funding of teaching hours? Anecdotal evidence from years of discussions with engineering colleagues brings up the following typical comments: 'We used to have written assignments/opportunities to submit drafts/presentations, but then the student numbers went up. .. the semester was shortened to 12 weeks so there's too much content to cover... X [the writing champion] retired... the faculty reduced the teaching budget...'. These comments do not pertain only to engineering faculties. But they are more pervasive, and writing practices are more invisible in the engineering curriculum.

This ongoing situation prompts two questions: why are writing practices invisible in the engineering curriculum, and how are they invisible? It is beyond the scope of this research to explain *why* writing practices are invisible in the engineering curriculum. The reasons are a complex mesh of interactions involving the historical development of the engineering curriculum, resources, time, entrenched beliefs about teaching, gender issues, and other factors.

The purpose of this thesis is to investigate *how* writing practices are invisible in the curriculum; to problematise the idea of the 'non-writing engineering curriculum'; to see how prevailing practices in the engineering curriculum constrain rather than enable writing practices. By exploring this problem, writing practices become visible and a language is provided with which to discuss the issues. Without this visibility and this language, writing practices in the engineering curriculum will continue to struggle to be seen as an integral practice of learning to become a professional engineer.

The following section introduces the research topic, including a brief introduction to the place that writing practices has in the context of higher education and of engineering studies in Australia. The research questions are then introduced, with an explanation of why this is an important area for research. The remainder of the chapter introduces the theoretical perspectives that have informed this work, followed by an outline of the thesis structure.

1.2 Context

1.2.1 Writing in higher education

The importance of writing in the academy is pithily summed up in the following epigraph: 'If it's not written, it's not research' (Evans & Gruba 2002, p. ii). Yet although writing is the way that most research and the majority of assessment is communicated and made material, there is something about writing practices in the academy which renders them 'marginalized, invisible, and taken for granted (Lee & Aitchison 2009; Kamler & Thomson, 2006; Thais, Brauer, Carlino, Ganobcsik-Williams & Sinha, 2012)' (Starke-Meyerring et al. 2014, p. A14). As Starke-Meyerring and colleagues note, this phenomenon has been observed by researchers in many countries, at all levels of higher education. Universities rarely provide space for writing practices, for learning the craft of scholarly writing; student cohorts and beginning academics alike are expected to know how to write 'academically' without explicit instructions. If members of a university do not know how to do this, they are regarded as requiring remediation – there is something wrong with their language, or their background, or their prior education so that they have not acquired these practices (Lea & Street 1998; Lillis 2006; Lillis & Turner 2001).

The lack of space for developing writing practices is not only an issue for student writers. In a recent study on the place of writing in academic work, Murray (2013) noted 'the absence of writing in academic workloads' (p. 86), notwithstanding the pressure for academics to research and publish. She suggests that the lack of visibility of writing in academic workplaces may mean it has less ‘cognitive weighting’ than other tasks which are present in workloads and visible in the workplace, and thus the place of writing in academic work is difficult to establish (2013, p. 86). It would seem from this that despite the centrality of writing in the university, the development of writing for students and the practice of writing for academics is neither central nor visible. The production of a written artefact is the focus of university work, yet the process of writing the artefact, and the learning and research that create the artefact, are not made visible.

One key reason that writing practices are not given space is that writing is often regarded as a skill – a skill that most people acquire in the early years of their schooling, and which is transferable to many different contexts. It is an everyday kind of knowledge. Yet writing is much more complex than knowing (implicitly or explicitly) the rules of grammar, spelling and punctuation. Writing is a practice: it is embodied, materially mediated, situated, relational and emergent (Rooney et al. 2015, p. 20). Writing responds to its context, its purpose and its audience. It is based on prior knowledge or understanding of some kind: technical knowledge, empirical knowledge, familiarity with the research and literature of a particular topic or circumstance. All writing practices are situated, and all require considerable time to learn how to become proficient; this is not always acknowledged by higher education institutions, or faculties, or degree programs, or university educators.

The marginalisation of academic writing in the university is seen by the proponents of academic literacy (including Lea & Street 1998; Lillis 2006; Turner 2004) as a consequence of the deeply embedded belief within the academy that language and knowledge are separate, and that language itself should unproblematically convey ideas. In this view, if language is doing its job, or is being used ‘correctly’, it is transparent or invisible; it is only when errors occur that it becomes visible and problematic (Turner 2004). This implies that the problem is individual students who are under-prepared, and thus it is solely the individual student’s responsibility to solve this problem by ‘fixing’ their writing – the deficit model of writing at university being regarded as a ‘skill’. The models of writing in higher education are explored in more depth in the literature review (Chapter 2) of this thesis, in Section 2.1.2.

In summary, writing practices struggle for visibility in universities, and are more often viewed as a skill than as a practice. The next section provides a snapshot of how writing is seen in the engineering curriculum.

1.2.2 Writing in the engineering curriculum

If writing is not seen as a practice in the academy at large, it has less chance of being regarded as a practice in the engineering curriculum with the prevailing view of engineering science as the dominant paradigm of engineering studies, and of knowledge and language as being separate. This is discussed further in chapters two and four, but an indication of the extent of the lacuna about communication, including writing practices, in the engineering curriculum is summarised in the following quotation:

> Study after study has pointed to the gap between the expectations of engineering employers for effective communication and the communication abilities of new engineering graduates (Bates & Connor, 1994; Pinelli, Barclay, Keene, Kennedy, & Hecht, 1995; Reave, 2004; Riley, Furth, & Zellmer, 2000; Sageev & Romanowski, 2001; Vest, Long, & Anderson, 1996). To address this gap, several studies have gathered evidence to describe the kinds of communication abilities engineers need on the job (Norback & Hardin, 2005; Pfeiffer, 1999; Ruff & Carter, 2009; Sageev & Romanowski, 2001; Vest, Long, Thomas, & Palmquist, 1995). (Ruff & Carter 2015, p. 125)

Ruff and Carter's study sought to prioritise engineering employers' expectations of communication abilities held by recent software engineering graduates; they concluded by suggesting: 'engineering educators [could] engage students in communicating via common engineering genres or types of communication', noting the importance of providing feedback on these tasks (2015, p. 141), with the strong implication that this does not currently take place.

It is difficult to ascertain where writing practices are developed within the engineering curriculum, even with a close examination of subject outlines or by mapping graduate attributes. Such investigations can reveal where writing does or does not take place, but may not indicate how writing in the context of the subject is practised, nor the level of writing practice required. There may be excellent writing practices in one engineering subject but these may not be developed in subsequent subjects. If writing practices are introduced, they are usually located in one or two subjects that are seen to be the domain of ‘soft skills’ development (engineering management, engineering communication), rather than being seen as part of the propositional knowledge, or ‘knowing what’ (Biggs & Tang 2007, p. 73) of content areas (Colman & Willmot 2016; Johnston & McGregor 2004). This both isolates writing practices as not being part of ‘real engineering’ and limits the opportunities for their development. The continued existence of writing practices is not guaranteed, even in subjects where they are supposed to be integral; changing circumstances (staffing, student numbers, budgetary constraints) can quickly cause them to be no longer practised, or to be downgraded to decontextualised written artefacts. Writing practices are fragmented, ad hoc and not seen as developmental; thus for students and for staff such practices are invisible. For example, first year engineering students at two Australian universities are not required to do any writing except for notation for six of the eight subjects (University A) and for seven of the eight subjects (University B), (Goldsmith, Willey & Boud 2012) and this trend continues in the ‘math-science death march’ (Goldberg 2011) of later year subjects.

Such an under-representation of writing either as process (practice) or as product (artefact) does not reflect what occurs in engineering practice. More than this, it seems to show that the engineering curriculum, or the individual engineering educators who in a large part enact the curriculum, do not see writing (whether in an instrumental function or as a vehicle for learning) as being an explicit element of the curriculum. Furthermore, it is unclear whose responsibility it is to develop writing practices or how they are to be developed; nor is it clear who among engineering educators feels confident to do so (Goldsmith & Willey 2016b; Kranov 2009; Mort et al. 2012; Skinner et al. 2012).

According to Australian engineering faculty graduate attributes and Engineers Australia competencies, the attainment of written (and spoken) communication skills in engineering students is an intended outcome of the Australian engineering curriculum:

‘Effective oral and written communication in professional and lay domains’ (Engineers Australia 2013, p. 2). As noted in the background to this chapter, engineering practice requires collaboration, coordination and communication, and writing practices contribute greatly to the effective practice of these activities. Employers certainly expect engineering graduates to be proficient communicators: ‘Employers expect recent [engineering] graduates to be able to communicate clearly and professionally. The expected abilities for communicating clearly include… being concise; giving sufficient explanation; and giving clear, high-level overviews’ (Ruff & Carter, 2015, p. 138).

The ongoing gaps in the engineering curriculum’s development of writing practices prompts the question of *how* such an important aspect of being an engineer and of doing engineering continues to be invisible in the curriculum and in academic practice.

Both the lack of visibility of writing practices in the engineering curriculum and the uncertainty about whose role it is to develop the graduate attribute of communication highlight gaps in the research in the role of engineering educators in this regard. Much of the literature focuses on initiatives for engineering students to develop or improve their writing, often with assistance from an ALL lecturer, within a subject or across an engineering program. Many of the strategies reported in the literature are optional adjunct subjects or resources (Carter, Ferzli & Wiebe 2007; Fischer 2015; Herrington 1985; Hilgers, Hussey & Stitt-Bergh 1999; Lord 2009; Mort & Drury 2012; Pflueger, Weissbach & Gallagher 2015; Shapiro 1991; Skinner et al. 2012; Wheeler & McDonald 2000; see also Mort et al. 2012 for their comments on the number of publications on developing engineering students’ writing). Literature on the perspectives of engineering educators about developing writing practices is less common and mainly examines the research writing practices of engineering educators and of their research students (Curry 2014; Gimenez 2014; Koutsantoni 2007; see also Blakeslee 1997) or the writing of practising engineers (Winsor 1990) and of engineering students becoming novice engineers (Artemeva 2009; Winsor 1996).

There have been studies which have examined engineering educators’ perspectives of writing in the curriculum: Jenkins, Jordan and Weiland (1993) surveyed engineering faculty staff about their beliefs and practices of engineering writing in the context of the role of writing in postgraduate engineering courses in US universities. Zhu (2004) compared business and engineering faculty members' views of student writing in their respective disciplines in one US university. Zhu's primary concern, like that of Jenkins and colleagues, is how to support ESL students in their disciplinary writing. Both studies have a similar context: they are set in American universities, where there are specific programs of writing instruction for all students, unlike Australian universities. An Australian context for the engineering faculty perspectives of writing is provided by Howard, Khosronejad and Calvo (2016), who examined engineering educators' views about writing and online tools to support the development of engineering students' communication capabilities. These and related studies are discussed in more detail in Chapter 2.

Overall, engineering writing practices from the perspective of engineering educators have been under-researched. There are few studies which look at how engineering educators experience writing: how they develop their writing practices, how they view writing in the engineering curriculum, how they view themselves as engineering writing practitioners, how or whether they see themselves as modelling writing practices for their students. The paucity of research in this area prompted a study to investigate engineering educators' perspectives of writing practices in the Australian engineering curriculum; specifically, the extent to which writing practices are visible or not within the teaching and learning of engineering studies – where the practices might be present but not seen, or where writing is regarded not as a practice but as a context-independent skill that should have been learned at high school.

1.3 Introducing the research questions

My research seeks to problematise the idea of the 'non-writing' engineering curriculum, where writing practices that extend beyond notation are seen to be outside the domain of engineering knowledge. It investigates the contributing factors to the invisibility of writing practices in the engineering curriculum, looking at how writing practices are made invisible. By doing this, it provides a lens and a language with which to view and discuss writing practices in the engineering curriculum. The investigation invites engineering educators to consider how and where they see writing practices in their discipline and their role in developing students' writing practices, not as writing instructors, but as practitioners and as role models for students, through providing opportunities for students to practise writing within the context of their engineering learning.

The questions that this study addresses are:

- How are writing practices invisible in the Australian engineering curriculum?
- What are the contributing factors that make them invisible?
- What are engineering educators' perspectives of writing practices in the engineering curriculum?
- What constrains and enables the development of writing practices as part of learning to become an engineer?

The main research question asks how writing practices are invisible in the engineering curriculum, with the understanding that this is not the totality of writing practices in the curriculum – that writing practices can be visible in the engineering curriculum, and that certain conditions can make them visible, but that the prevailing situation is of invisible writing practices. The term 'invisible writing practices' is employed in this study to convey a range of meanings – to refer to (often excellent) writing practices which exist but only in isolated contexts; which exist but are separate from the engineering curriculum; which exist but are not acknowledged; which once existed but have fallen into disuse; which should be practised but are ignored or regarded as someone else's responsibility; and to refer to writing practices which are missing.

The contributing factors are those within the case studies of the engineering educators participating in this study, as explained in detail in Chapter 3. The constraints and enablements are those found within the case studies, with reference to the context of the institutions in which the case studies are based. Constraints and enablements, as noted by Kemmis, Wilkinson and Edwards-Groves, 'are obverse sides of the same coin. Together they direct and limit what is said, what is done, and how people relate to one another and the world' (2017, p. 243).

The next section of this chapter situates the study in the context of the engineering curriculum in Australia, which varies slightly from that of engineering curricula in the UK and in the US, but which shares many commonalities, as recognised by the Washington Accord (International Engineering Alliance 2014).

1.4 The engineering curriculum and writing

The following definition of engineering, from Engineers Australia, provides an understanding of engineering in practice, and of how engineers perceive their work and their role in society.

> Engineering, science, technology and innovation are very closely linked and interrelated but they do not have the same meaning. Engineering is a creative activity based on science, mathematics and technical knowledge applied with art, skill and the management of both risk and stakeholder expectations in a way that is sustainable for the benefit of future generations. Engineers marshal science and technology to create new artefacts and services. To engineer literally means 'to make it happen'. (Engineers Australia 2009, p. 8)

The Engineers Australia definition refers to art, creativity, applied knowledge, managing stakeholder expectations, and creating artefacts and services. These activities necessarily involve collaboration, coordination and communication. The view of engineering as a creative activity that benefits society is a key reason that many students choose to study engineering (e.g. Joordens, Chandrasekaran, Stojcevski & Littlefair 2012). Yet this vision of engineering is contradicted by the narratives of engineering and images of engineers as poor communicators; a slogan on a University of New South Wales engineering t-shirt from the late 70s proclaimed: 'Three years ago I couldn't spell "engineer" and now I is one!' and a more recent example from the US says: 'Just think — four years ago I couldn't even spell injuneer and now I are one' (Popik 2012). The social awkwardness of engineers and engineering students is well-established, even by fellow engineers; Wulf and Fisher refer to the stereotype of 'the asocial geek' (2002, p. 36). Another stereotype is nerds in hard hats: 'They're not just dudes in hard hats, you can also see girls in hard hats too' (Savage 2015). The conception of engineering as being solely or mainly about technological wizardry and technical fixes occurs frequently in popular culture, and in promotional materials for engineering courses at university: images of robots and rockets tend to feature heavily. Engineers do not come across as smooth operators with excellent coordination and communication skills, nor do these images represent 'a creative activity based on science, mathematics and technical knowledge applied with art...' (EA 2009, p. 8). The creative engineer seems to have been lost in translation. In fact, there is a tension between practising engineers and engineering educators about the emphasis on engineering science in the curriculum, as noted in the King report (2008, p. 68).

Opportunities to be creative and to develop coordination, collaboration and communication should be prominent in the Australian engineering curriculum, according to decades of research into engineering education and widespread calls for a more practice-based emphasis to the curriculum (e.g. King 2008; Lloyd et al. 2001) which has sought to incorporate collaborative approaches such as project and problem-based learning. There have been significant innovations in approaches to teaching engineering, such as the adoption by several engineering faculties, at least in principle, of the CDIO (conceive, design, implement, operate) syllabus (Crawley et al. 2007) to ensure that there is authentic learning and assessment of problem-based learning at all levels of the engineering degree. Some change has been achieved, albeit not at a rapid pace. However, engineering students are still predominantly taught in a traditional lecturing style which emphasises knowledge transfer that can be assessed through short answer examinations. The engineering curriculum is still predominantly focused on assessment tasks that require calculations, reproducing the correct equations, or solving well-structured problems, or require a narrow range of writing practices, or emphasise neatness and correctness of solutions, but do not demand analysis, critique or evaluation (e.g. Godfrey & Parker 2010; Zhu 2004). It seems that the development of the creative engineer who can collaborate, coordinate and communicate is invisible in the curriculum, obscured by the focus on the acquisition of technical knowledge.

The engineering curriculum does not generally allow for the development of argumentative or persuasive writing practices, as problems are mostly right or wrong;

moreover, students are not encouraged to put forward arguments as to which method is better for solving certain problems. One explanation for the narrow range of communication capabilities being developed in the curriculum is provided by Trevelyan, who observes that a commonly held view of engineering communication is one of 'an information output transfer process, from the engineer to the client...It is possible that this difference could explain why employers complain about graduates' communication skills while graduates think they can communicate well' (Trevelyan 2009, p. 6). Trevelyan's observations are borne out by engineering textbooks which still use Shannon and Weaver's (1949) communication model, which represents communication as information encoded by the sender and decoded by the receiver.

Another reason for argumentation being underdeveloped as a skill in the engineering curriculum probably relates to the belief held by engineers that technology speaks for itself, and does not need interpretation (Winsor 1996). This view of technology can be linked to the dominant perspective that the engineering curriculum should follow the model of engineering science. 'Engineering as an academic discipline is founded on engineering science' (Johnston, Lee & McGregor 1996, p.128); Wulf and Fisher refer to 'the so-called "engineering science" model…which emphasizes the scientific and mathematical foundations of engineering, as opposed to empirical design methods based on experience and practice' (2002, p. 35). The emphasis on engineering science may or may not cause writing practices to be invisible, but it does not provide room for them to be developed, possibly due to a competition for scarce resources in an already crowded curriculum.

There is thus a lack of enactment of writing in the curriculum, with the associated disengagement of the development of writing in the discipline by faculty staff (e.g. Goldsmith & Willey 2016b; Kranov 2009). This is evident in engineering faculties throughout Australia and overseas, despite ongoing concerns about gaps in the development of engineering graduate capabilities of written (and spoken) communication, and of the quality of writing of engineers (Appleby et al. 2012; King 2008; Male, Bush & Chapman 2011; McKenna 1997; Mort & Drury 2012; Trevelyan 2009, 2010).Therefore it is important to explore what is happening: how is such an important aspect of being an engineer and of doing engineering rendered invisible as enacted in the curriculum (and in academic practice)? The importance of written and spoken communication is clearly demonstrated by its inclusion in engineering faculty graduate attributes and in Engineers Australia's key elements of competency (as discussed in the literature review in Chapter 2); Table 1.1 shows the graduate attribute of communication as expressed by four Australian engineering faculties in three different states. Yet the responsibility for the development of this attribute, and the visibility of writing in the engineering curriculum are much less obvious.

Table 1.1: Graduate attribute of communication from four engineering faculties in Australian universities

QUT (QUT Engineering accreditation 2007 vol. 1 p. 85 table 19)	U MELB (Faculty of Engineering accreditation 2007)	UNSW (UNSW Faculty of Engineering website 2009)	U SYD (Faculty of Engineering & IT – Unit of study database 08)
Effective communication in a variety of contexts & modes	Communication	Ability to communicate with each other, with other professional groups & with the general community	Ability to communicate effectively in diverse social & professional contexts

As writing is not only a necessary attribute for engineering practice, but also a key element of learning and a means of clarifying one's thinking and of exploring ideas, its development needs to be both acknowledged and made visible in the engineering curriculum, so that students and engineering educators alike can engage actively in the discourse of engineering. However, the development of written (and spoken) communication is often overlooked or squeezed out of a busy curriculum, as noted by Skinner and colleagues.

> Frequently, though, there is little space devoted explicitly to communication skills in the engineering curriculum. The implication to students may be that learning support resources are an optional extra to be used only if they have time and the resources are considered convenient to access. (Skinner et al. 2012, p. 1)

The notion that it is up to individual students to develop their communication skills via the 'optional extra' of learning support resources can often result in the students who most need support being least likely to seek it out (Skinner et al. 2012, p. 5).

The lack of opportunity to develop the skills of argument, persuasion and negotiation can have negative consequences, as observed by Winsor:

> …in order to be effective, engineers must be skilled users of rhetoric. Because cultural beliefs about technical knowledge and the actual needs of engineering practice conflict, it is possible that the effectiveness of engineers is diminished and that the professional development of young engineers is needlessly retarded. Such consequences are not only frustrating for engineers but also potentially harmful to society at large because they can result in inferior and even dangerous products. (1996, p. 2)

Winsor argues that not only is there a lack of opportunities for engineering students to develop what she terms rhetoric, there is a lack of recognition within the engineering profession of the need to be persuasive. She provides the example of the space shuttle Challenger explosion in 1986, where communication failures were seen to be key elements in the chain of events that caused the disaster:

> The existence of data alone was insufficient to create knowledge. People needed to persuade one another of the meaning of the data they had, but they failed to do so partly because they did not seem to know such persuasion was necessary. (1996, p. 3)

There are many similar examples of engineers not having or not being given a greater role in negotiating, because they are not perceived as having strong communication skills, or because they themselves lack confidence in how they communicate in writing. For example, Paretti and McNair’s (2012) study of discourse identities in engineering work presents a case study of a manufacturing company where engineers are narrowly positioned as technical experts, and where key decisions are made by the marketing team. The lack of visibility of the role that writing practices have in engineering practice and in the engineering curriculum emphasises the criticality of engineering students learning how to argue, debate and persuade. Engineers should be expected to do more than create artefacts and services; they should be able to conduct reasoned debates about what, how and whether the creation of such artefacts and services needs to take place. They should be leading popular opinion rather than being merely the servants of industry. These rhetorical skills need to be introduced as a key part of engineering studies. Leaving them to be somehow developed during engineering practice suggests an abrogation of responsibility by the engineering curriculum and by those who design, administer and implement it. This need underscores the importance of the investigation into the invisibility of writing practices, and stimulates further questions. How do engineering educators perceive writing in the engineering curriculum? How do they perceive the writing that they and their students do? To what extent do engineering educators perceive writing as developmental, as practice? To what extent do engineers in the academy see themselves as role models for writing as part of doing engineering, and of becoming an engineer?

The following chapters of this thesis seek to explore these questions and to provide a deeper understanding of the issues involved.

Chapter 2 reviews the literature of the theoretical perspectives which inform this study; it considers the models of writing that are in use in higher education and describes the predominant views of writing practices in the engineering curriculum. It raises the suggestion that writing practices are 'othered' in the engineering curriculum, which is developed further in Chapter 5. Practice theory perspectives are then introduced as both a theoretical and a methodological lens with which to approach the research questions.

Chapter 3 outlines the methodology and methods used in this study, explaining the evolution of the research methods adopted and how practice architectures theory is used as both a theoretical and a methodological lens to investigate the case studies on which this research is based. The chapter then introduces the nine engineering educators who are the participants in this study, and whose teaching practices form the case studies, and describes how the data were collected and analysed.

Chapters 4, 5 and 6 are the findings and discussion chapters. **Chapter 4** argues that writing practices are mostly unsupported in the engineering curriculum. It outlines what unsupported writing practices means, using the lens of practice architectures theory with the sub-theory of ecologies of practices, and discusses how writing practices are supported or unsupported in the case studies.

Chapter 5 explores the notion of the otherness of writing practice in the engineering curriculum, and considers the perspectives and practices of the participants which position writing practices as other within the case studies. It discusses case studies where writing practices are not seen as other, and considers the contributing factors that cause writing practices to be othered.

Chapter 6 argues that the prevailing practices of othering writing and of not supporting writing practices interact to render writing practices invisible in the engineering curriculum. It outlines how this has come about, using evidence from the case studies, but argues that under certain conditions writing practices can become visible and embedded in an engineering program, as exemplified in one of the case studies.

Chapter 7 is the final chapter**,** which pulls the strands of the thesis together, including suggestions for future directions for this research. It concludes by sketching a possible way forward to make writing practices both visible and invisible – by firstly making them part of what student engineers learn, and then by making them integral to ways of learning to become an engineer.

Chapter 2
Literature Review

The purpose of this chapter (Chapter 2) is to provide a literature review that outlines the key issues relating to the research problem, and the approach used to explore the research questions, building on the questions raised in Chapter 1. This chapter is organised as follows. The first section presents and discusses the implications of different perspectives; it establishes what is meant by writing practices, both in the context of higher education and more specifically within the engineering curriculum. The second section discusses perspectives of invisibility of writing practices and how they are used in this research. The third section explores the types of knowledge that are privileged in the prevailing engineering curriculum in Australia and what impact this has on writing practices. The fourth section looks at practice theories and how they can be applied to research on perspectives of writing practices within the engineering curriculum, with a particular focus on practice architectures theory. The conclusion of this chapter revisits invisible writing practices in the engineering curriculum to clarify how this concept has been interpreted in my research.

2.1 What are writing practices in higher education?

To appreciate how writing practices are viewed in the engineering curriculum, it is useful to understand the different perspectives of writing practices in higher education overall, and how these perspectives carry over into the discipline of engineering. Chapter 1 outlined how writing in higher education occupies a contested place; on the one hand, writing is still the main form of assessment at university, but on the other hand the practice of writing continues to be marginalised (Starke-Meyerring et al. 2014; Turner 2011), both for students (Curry & Lillis 2003) and for academic staff (Murray 2013). The need for 'oral and written communication skills to be made more visible, accessible and, importantly, integrated within specific disciplinary contexts' (Department of Education, Employment & Workplace Relations [DEEWR] 2009, p. 2) in Australian higher education was identified in The Good Practice Principles for English language proficiency (DEEWR 2009). The Good Practice Principles were developed in response to a growing awareness in Australian higher education of the importance of communication skills for graduate employment, and of the need to better support English as an additional language (EAL) students' language development. The principles both acknowledge the disciplinary nature of academic literacies in higher education and recognise that they are generally neither very visible nor integrated into the disciplines. While it is the norm for university and college students in the US to undertake writing subjects ('composition courses') in their freshman year and often throughout their degree, this is not the case in Australian universities. The consequence is that academic writing is not generally taught or specifically developed in the curriculum, or it is seen as a 'bolt-on skill' to be taught in workshops, often by adjunct academic staff such as ALL lecturers, student learning advisers or information literacy staff. The workshops may be discipline-specific or generic, and are frequently seen as remedial, both by faculty staff and by the students who are 'invited' or encouraged to attend. It is unusual for them to be seen as developmental; it is also unusual to see faculty staff taking the initiative or responsibility for developing writing.

A partial explanation for the lack of visibility of writing practices in higher education may relate to institutional perspectives of writing. This affects the extent to which writing is regarded as a practice that is integrated into the disciplinary curriculum in tandem with the development of disciplinary knowledge and discourse, or is isolated as a decontextualised skill. Perspectives of writing in higher education can be categorised by four main models or approaches: study skills, academic socialisation, academic literacies (Lea & Street 1998; Wingate 2006) and the discourse of writing as a social practice (Ivanic 2004; Lillis 2008; Turner 2011). These models can be seen as forming a continuum; for example, writing as a social practice incorporates academic socialisation and an academic literacies approach. Each model is explained in more detail in the following paragraphs.

The most reductive of these models is the 'study skills' approach. It is often referred to as the 'deficit' model, whereby students are assumed to enter the academy with sufficient academic literacy to be able to deal with the demands of higher education. Those students who are deemed to be academically under-prepared – lacking time management, knowledge of academic referencing conventions and academic literacy – are remediated through study skills programs. As Lea and Street note, 'The study skills approach has assumed that literacy is a set of atomised skills which students have to learn and which are then transferable to other contexts' (1998, p. 159). This approach emphasises the teaching of surface features of language: spelling, punctuation and sentence-level grammar, decontextualised from disciplinary knowledge. The perspective of 'writing skills' is critiqued by several authors (e.g. Lea & Street 1998; Wingate 2006, 2007), who point out that the separation of writing from the content and context in which the writing takes place will result in remediation for those individuals who choose to attend generic writing workshops but will make no lasting changes to improving students' disciplinary literacy overall. Students may learn how to structure an essay but not how to answer an assignment question that requires them to integrate information and construct an evidence-based argument (Wingate 2007).

Although the majority of academic literacy specialists working in Australian universities do not share the view of writing as study skills, it is widely held by university managers, student support service providers (Bury & Sheese 2016; Lea & Street 1998; Williamson & Goldsmith 2013) and by many disciplinary academics, who see 'writing skills' as separate from the content knowledge of their discipline (e.g. Goldsmith & Willey 2016b; Kranov 2009; Mitchell 2010). Bury and Sheese make the point that disciplinary academics may have forgotten the difficulties of acquiring the language and conventions of their discipline, so that '…faculty may take this knowledge for granted, and focus on disciplinary content in the classroom without articulating or addressing the whole area of academic literacies in a disciplinary context' (2016, p. 3).

Amongst the limitations of the study skills approach, with its offerings of generic writing skills workshops, is the failure of these workshops to attract those who most need the support (Arkoudis & Starfield 2007), and to perpetuate the view within the disciplines that learning to write in the academy is firstly unproblematic, and secondly someone else's responsibility.

> Targeting academic reading, essay writing, or problem solving with generic, decontextualised courses implies that they are context-independent techniques that can be practised in the void. However, they are complex tasks

> that require subject knowledge and, above all, an understanding of the nature of knowledge in the specific discipline. (Wingate 2007, p. 394)

Wingate identifies the typical landscape of academic writing instruction – the commonly held conception that university students should already know how to read and write for a higher education context, and that the context is uniformly applicable to all students. Academic staff who hold this conception thus absolve themselves of the responsibility to develop their students' writing, allowing their focus to be solely on the 'content' of the subjects they teach, and assuming that poor writing can be fixed by decontextualised writing workshops.

Academic socialisation 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). It is 'based on the belief that there are different literacies in different contexts, so that students need to learn the specific characteristics of academic writing, and of the disciplinary culture into which they are entering' (Ivanic 2004, p. 222). It is exemplified in the Writing in the Disciplines (WID) approach, where the student writer is being socialised into the expert writing of the discipline. Academic socialisation 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.

An example of academic socialisation in STEM disciplines is a study conducted by Carter, Ferzli and Wiebe (2007) at a university in the US that specialises in science and engineering. The authors posed the question: where is the evidence that WID encourages learning in the disciplines? Students in their responses to the questions demonstrated an awareness of the act of writing itself: the experience of synthesizing, ordering, reflecting and interpreting that leads to learning (2007, p. 288). While this study clearly shows that students are aware of and appreciate the value of writing to learn, and of participating in apprenticeship genres, it also raises questions around power, control and legitimate peripheral participation. One question is the extent to which socialisation into the discipline is or should be the ultimate goal of education, excluding as it does the issues of power and conflict that often underlie the experiences of students attempting to acquire a university qualification. These sites of conflict are explored in the perspective of academic literacies, which is discussed below. A related question raised by Carter, Ferzli and Wiebe's study is the extent to which the experts or 'old-timers' (Lave & Wenger 1991) know how to model and pass on their knowledge of the disciplinary language. This is by no means a given in STEM disciplines, as noted by Blakeslee: 'In science, for example, [scientists] seldom receive explicit instruction in writing or, of greatest importance here, in the teaching of writing' (1997, p. 155). The socialisation approach does not take into account the likely eventuality that many academics will not model writing, nor provide time to practise a range of writing tasks in their subjects. It does not consider what happens when lecturers are not proficient writers themselves, either because they are teaching in their second language or because they are products of a curriculum that does not practise or develop writing.

A third question concerning the WID perspective that students are legitimate peripheral participants being socialised into the discipline of their choice, is whether apprentices (students) are able to challenge or criticise the discipline they are entering. Johnston, Lee and McGregor (1996) critique the discourse of engineering on this point, as they see that contemporary engineering education limits the possibility that students will challenge the dominant paradigm. In order for any discipline to change and evolve to meet current circumstances, there need to be opportunities for those entering and within the discipline to influence the direction of the pursuit of knowledge. The WID model would seem to limit the scope for such influence.

Academic literacies (e.g. Lea & Street 1998; Lillis 2006; Lillis & Scott 2007; Turner 2004, 2011) is a theoretical perspective from the New Literacy Studies (NLS) movement which takes an ethnographic approach to literacy, situating it in social, cultural, historical and political practices (Gee 1999). Academic literacies builds on the WID approach in terms of co-constructing knowledge, but it attempts to problematise the role of the writer and the types of writing required of the student: 'what marks out those [approaches] which can be characterised as adopting an "academic literacies" approach, is the extent to which *practice* is privileged above *text*' (Lillis & Scott 2007, p. 10; emphasis in the original). The plural form of literacies is used to signal the critical theory on which academic literacies research in the UK and in Australia is generally premised (Lillis & Scott 2007). The academic literacies model 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. This model provides opportunities for researchers to investigate (mainly student) perceptions of different writing practices, and for students themselves to see how to shift from everyday literacy practices to academic literacy practices (e.g. Lillis 2001; Lillis & Turner 2001). Student writing has continued to be the focus of academic literacies in higher education research in the UK and in Australia, as evidenced in Lillis and Scott (2007) and in database searches of the key journals in this field. It adopts a transformative stance, asking student writers and academics to challenge the dominant types of writing at university.

While academic literacies has much to offer as a theoretical perspective and as an approach to teaching writing in higher education, it has limitations. Firstly, as noted by Bury and Sheese (2016), it lacks pedagogical models or frameworks to implement an approach on a wide scale. Secondly, the emphasis is mainly on student writers and their practices, and how students can be supported to challenge 'dominant literacy practices' (Lillis 2006, p. 34) through dialogues with their tutors. However, the likelihood of this taking place has been critiqued by several authors; for example, Wingate (2014) notes that the resources required for individual tutor-student dialogues are not always available. From an Australian perspective, it would be safe to say that such dialogues would be the exception rather than the rule. Wingate also points out that beginner student writers are not in a position to challenge dominant literacy practices as they are unfamiliar with what those practices are (2014, p. 107).

The model of discourse of writing as a social practice has been developed by researchers in academic literacies such as Roz Ivanic and Theresa Lillis. Ivanic (2004) defines discourses of writing as 'constellations of beliefs about writing, beliefs about learning to write, ways of talking about writing, and the sorts of approaches to teaching and assessment which are likely to be associated with those beliefs' (2004, p. 224). Although this approach shares many commonalities with the theoretical perspective of academic literacies, discourses of writing as a social practice are less focused on student writing in the academy. Ivanic has developed a 'discourses of writing framework' which identifies six main discourses: a skills discourse, a creativity discourse, a process discourse, a genre discourse, a social practices discourse and a sociopolitical discourse (2004, p. 225). Her framework categorises each discourse according to beliefs about writing and learning to write, and approaches to the teaching of writing. The genre discourse is anchored in the understanding that writing consists of text types which are shaped by social, cultural and situational contexts. A hallmark of the genre discourse is the explicit teaching of text types so that (student) writers learn the features and structures of different types of writing and can write appropriate texts for specific purposes. The social practices discourse builds on academic literacies but has a broader focus in academic writing research to include the writing of academics (e.g. Gimenez 2014; Gimenez & Thondhlana 2012). Central to this discourse is its emphasis on the practices of writing rather than only on the texts produced by writing, such as the 'talk around texts' (Lillis 2001). Ivanic's framework, in combination with the theory of systemic functional linguistics, has informed the current research, as they incorporate both a genre discourse and a social practices discourse. Importantly for this study, both the genre discourse and the discourse of writing as a social practice focus on writing as a practice that is socio-culturally and historically motivated and oriented.

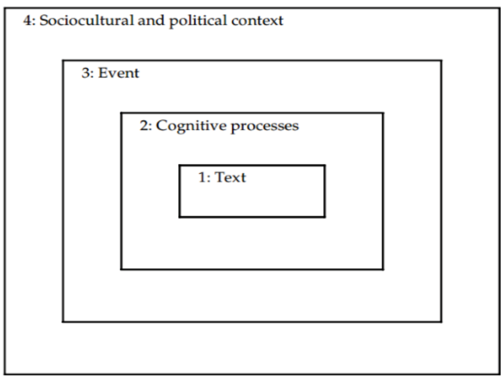

Figure 2.1: Ivanic's multi-layered view of language (Ivanic 2004, p. 223)

This is represented in Fig 2.1 as a series of nested boxes (Ivanic 2004), with text (spoken or written) at the centre; the second layer comprises the cognitive processes used to create the text; the third layer is the event, the immediate context in which the text is being produced, including its purpose, while the fourth layer is the broader sociocultural and political context – the social structures and power relations that interact with the text. In genre discourse Halliday and Martin (1993) use concentric circles to represent the relationship between language and the context in which it is used; layer three is referred to as the context of situation and layer four is called the context of culture. Both discourses regard language as shaping and being shaped by its sociocultural context. 'A sociocultural-centred perspective views language as the means to construct interactions, thus placing significance on the ways that spoken and written discourse construct literacy' (Brown, Reveles & Kelly, p. 780). It provides ways of discussing beliefs about the writing that academics and students do and can provide an opportunity for academics to make those beliefs more visible or more explicit. The genre discourse can encourage academics to provide models of the text types they are asking their students to produce. For example, as Gimenez and Thondhlana observe in their study of collaborative writing practices of engineering educators and their research students: 'engineering students should be encouraged to analyse typical genres, such as design projects, together with the social and organisational practices in which these genres are embedded' (2012, p. 484) in order to understand the context and purpose of engineering writing practices. In addition, the discourse of writing as a social practice allows writing to be spoken of as a practice rather than as a skill, thus decoupling it from the notion of being a context-independent, generic action (Sørvik & Mork 2015). The following section discusses writing as a practice in more detail, particularly in the context of the engineering curriculum.

2.1.1 What are 'writing practices', and what are writing practices in the engineering curriculum?

The previous section outlined perspectives of writing in higher education, including my own perspective, which incorporates the genre discourse and writing as a social practice. This section clarifies the use of the term writing practices in the context of the engineering curriculum. As mentioned in Chapter 1, a practice is defined by Rooney and colleagues as embodied, materially mediated, situated, relational and emergent (Rooney et al. 2015, p. 20). This definition aligns with Yagelski's view of writing as simultaneously a physical, emotional and intellectual act (Yagelski 2012, p. 192). Writing does not exist in isolation but shapes and is shaped by its sociocultural context. Writing as a practice responds to its context, its purpose and its audience. To see writing as a practice means to see it as inextricable from the circumstances that generate the writing, and to see its sociomateriality. Lillis, in her discussion of language as practice, suggests that language (written or spoken) should be considered as 'a practice-resource' (2001, p. 34), and claims that the idea of practice in 'specific relation to literacy… "offers a powerful way of conceptualising the link between the activities of reading and writing and the social structures in which they are embedded and which they help to shape"' (Barton & Hamilton 1998, p. 6 in Lillis 2001, p. 34). By speaking of writing as a practice, and particularly as a knowledge-making practice (Starke-Meyerring & Pare 2011), researchers can help to bring academic literacy in from the margins (e.g. Stevenson & Kokkinn 2007) and anchor it in a disciplinary context. If disciplinary literacy practices are contextualised they can be seen as part of the developmental learning of students to become members of their academic and professional community. This in turn can integrate the development of literacy practices as part of the teaching of subjects in the disciplines. Making this knowledge explicit can also encourage disciplinary academics to recognise the writing conventions and practices of their fields, and of which they have (at least) tacit knowledge which can be modelled for their students.

Having explored the idea of writing as a practice, the next section discusses writing practices in the engineering curriculum.

2.1.2 Writing practices in the engineering curriculum

Writing practices in the engineering curriculum include all the types of writing that take place as part of the engineering curriculum, whether this is notation of numbers, formulae, equations or calculations, or writing the diverse range of reports required in different subjects, or of capstone projects or of honours theses (see Winsor 2006 for an extended discussion of what counts as writing in engineering).

Table 2.1: Types of writing practices in the engineering curriculum and examples

Type	Example
1. Form-filling	Completing a template
2. Drawing & sketching	Freebody diagrams
3. Numerical notation	Noting measurements in lab sessions
4. Formulae & equations	Using formulae to solve problems (in labs or lectures)
5. Short Report writing < 3 pp.	lab reports, computer reports
6. Extended report writing > 3 pp.	Field reports, project reports (group or individual)
7. Reflective writing	Reflective journals, reflective reports
8. Thesis or capstone project	Honours thesis, capstone project (group or individual)

Source: Engineering subject outlines, various Australian engineering faculties 2012-2017

Table 2.1 provides a snapshot of the main types of writing practices in the engineering curriculum, but it is not an exhaustive list. Many types of writing practices are found in the one document, such as a field or lab report that will require notations, equations, freebody diagrams and report writing. Although all the listed writing practices would be part of engineering practice (see examples listed in Writing@CSU 2017), the majority of engineering students have opportunities to practise only those numbered 1-4 in their curricular studies (e.g. Goldsmith, Willey & Boud 2012; Jenkins, Jordan & Weiland 1993; Zhu 2004). During the course of their studies, students will be assessed on at least seven of the eight text types (reflective writing occurs in some engineering degree programs but not all), but will have far fewer chances to practise these text types in class, online or for homework, or to receive formative feedback. Where opportunities are provided to practise more extended writing or more complex text types such as types 5-8, they are usually part of a specific intervention (e.g. Hilgers, Hussey & Stitt-Bergh 1999; Wheeler & McDonald 2000; Yalvac et al. 2007).

2.1.3 Writing practices of engineering educators and engineering professionals

There are clear contrasts between the writing that is practised by most engineering students in the curriculum and the writing practices of engineering educators, and of engineering professionals. The differences include not only the amount of writing required by the latter two groups (see e.g. Trevelyan 2007), but also the range of text types and of purposes for writing. Table 2.2 shows the writing practices of engineering educators as reported in the literature and by the participants in this study; many of the writing practices of engineers involves writing as negotiated meaning. As can be seen from comparing the two tables, there is little overlap between the predominant writing practices of students and of practising engineers and engineering educators, which highlights the gap in the curriculum of developing writing practices. It also raises again the question of where students might develop the writing practices in columns 5-8 in Table 2.1; they are the dominant practices of professional and research engineers, but are not frequently practised in the curriculum. The role and importance of writing in engineering practice has been acknowledged by engineering professionals in numerous studies and reports, but the centrality of writing to engineering practice is less readily acknowledged by the majority of engineering educators (e.g. Colman & Wilmot 2016; Goldsmith & Willey 2016a; Johnston & McGregor 2004; Kranov 2009).

Table 2.2: Types of writing practices reported by professional & research engineers

analyses, progress reports, incident reports, forecasts, plans, proposals, recommendations, action reviews, work descriptions, detailed project descriptions and reports, patents (reddit.com accessed 17.10.17)
Project documents (scoping, conceptual design, recommendations, conceptual report, sketches with notes, site instructions), evaluative reports for clients, tenders, presentation notes, lecture notes, research articles, conference papers; chapters in books; grant applications, consulting reports, lab reports, journal articles, chapters in books, thesis, project reports, team project reports, emails, telexes, writing in a log book (participants from this study)
Journals/transactions; supporting text for software; course syllabi; feasibility studies; guidelines; equipment reviews (Orr 1999, p. 35)

As noted in Chapter 1, concern about the writing abilities of engineering students and of engineering graduates is not new; there have been a wide range of studies, initiatives, strategies and programs, particularly in the US and in Australia dating from at least the 1980s, to investigate and develop engineering students' writing abilities (e.g. Carter, Ferzli & Wiebe 2007; Fischer 2015; Herrington 1985; Hilgers, Hussey & Stitt-Bergh 1999; Mort & Drury 2012; Shapiro 1991; Skinner & Mort 2009; Wheeler & McDonald 2000; Yalvac et al. 2007). The majority of interventions reported in the literature cover the gamut of writing development models (Lea & Street 1998) from study skills to socialisation within the discipline to academic literacies and generally provide models, exemplars and scaffolded writing exercises around authentic tasks. The US examples sometimes utilise the first year composition or communication courses to introduce engineering topics and report genres (e.g. Artemeva 2009, 2011;

Pflueger, Weissbach & Gallagher 2015). Unfortunately, most of these interventions lack sustainability. The intervention, no matter how well-considered, timely, relevant and effective, is likely to disappear as soon as the writing champions move on, lose funding, undergo an organisational restructure or collapse from exhaustion. This is despite the reality that

> [w]riting is a central activity whilst at university...as it is often core to teaching and assessment in most subjects. It is what students do, it is what is required of them, and is therefore an integral part of how students make sense of the world of university and higher education. (Appleby et al. 2012, p.2)

An Australian example of this is the WRiSE (Writing Reports in Science and Engineering) site (Mort & Drury 2012; Skinner et al. 2012). The authors outline the development of an online writing resource for students in engineering and science in Australian universities – a collaborative effort by academic literacy specialists and engineering and science educators. Student responses to the site showed it was regarded as highly effective; faculty staff commented that it was a very useful resource, yet the authors indicate that faculty staff do not promote and encourage students to use the site unless prompted by learning advisers. This suggests that the majority of faculty staff do not appear to share the responsibility for developing student writing in their disciplines, even when a resource such as an online writing site is readily available. It seems almost impossible to embed writing practices permanently in the engineering curriculum so that they are seen to be an integral element of becoming an engineer, and therefore deserving of space within engineering programs. In other words, it is very difficult to make writing practices visible in the engineering curriculum, and much of this difficulty appears to stem from the engineering faculty staff perspective that the development of writing practices does not fall within their domain. As noted in Chapter 1, this perspective has been under-researched, with some exceptions.

Studies which examine engineering educators' perspectives of writing in the curriculum include Jenkins, Jordan and Weiland (1993), who surveyed engineering faculty staff about their beliefs and practices of engineering writing in the context of the role of writing in postgraduate engineering courses in US universities. As part of the study, they investigated whether there were differences in attitudes and practices when teaching international non-native speaking (NNS) students as opposed to local native speaking (NS) students. They found that 'for the engineering programs surveyed in this study, writing experiences were not an integral part of the graduate program' (1993, p. 61), and that faculty staff expected less of the international students than of the local students in terms of writing proficiency. Faculty staff reported that they rewrote significant parts of their research students' theses: approximately 11% of NS students' theses, and on average 25% of the thesis (but sometimes as much as 37%) for NNS students; several staff commented that this placed a significant burden on them as supervisors (1993, pp. 61-62). Jenkins and colleagues were researching from the perspective of teachers of English for Specific Purposes (ESP) in US universities, seeking to find out how they could develop NNS graduate students' writing in engineering studies. Team-taught writing courses were proposed as a possible solution, where ESP teachers and engineering educators would co-teach aspects of discipline-specific writing. However, the authors conceded that faculty staff might need considerable convincing to participate, despite the benefits to their students and the potential decrease in their own workload. It is interesting to note that although the study was conducted in the early 90s, little seems to have changed in the interim in regard to perspectives of writing in the engineering curriculum – in this case, the postgraduate curriculum.

Another study which investigated engineering educators' attitudes towards writing in higher education is that of Zhu (2004), who compared business and engineering faculty members' views of student writing in their respective disciplines in one US university. Although both faculties saw writing as very important for their students' future success, there were contrasting approaches to the development of writing – the business faculty sought to integrate writing into most, if not all courses (subjects), whereas it was seen as a much less prevalent aspect of learning by engineering faculty. The reasons given by engineering faculty related to disciplinary culture: both the quantitative nature of the discipline, and the belief that engineering students are not interested in writing. Zhu found that 'the faculty focused on content when commenting on student writing, and opportunities for students to act upon the feedback and revise were not common' (2004, p. 43), indicating a view amongst faculty staff (from both business and engineering?) of the separation of writing from content, bearing out the findings from other literature. Zhu's perspective, like that of Jenkins and colleagues, is that of a writing instructor working predominantly with English as a second language (ESL) students; her primary concern is how to support ESL students in their disciplinary writing. Other commonalities between the findings of the two studies are notable – in both cases, writing is seen as important for engineering students, but how they develop it is not the concern of engineering faculty. Both studies have a similar context: they are set in American universities, where there are specific programs of writing instruction for all students, unlike Australian universities.

A thought-provoking study conducted by Leydens (2008) of 'engineering insiders' – engineering students, engineering educators and industrial engineers – investigated their attitudes towards engineering writing with a specific focus on the role of rhetoric (Australians would refer to this as 'persuasive' writing) at university and in the workplace. His participants (eight in total) were placed on a 'rhetorical awareness continuum' (p. 252) which indicated the degree to which they saw persuasive writing to be relevant to engineering. The continuum included characteristics such as: role of writer; role of reader; writer identity; and the role of objectivity. The study is highly relevant to the findings of this research, as it notes the invisibility of persuasiveness in engineering writing at university, and the tendency for some of his participants to separate their writer selves from their engineering selves. While none of the participants denied the role of rhetoric in engineering writing, the two student participants were the most inclined to play down the importance of persuasion in their engineering writing, to see readers more as data recipients than as data interpreters and to see their writer identity as minimal. The other participants occupied various positions on the continuum, but generally saw the role of writers and readers as more active and interactive. Leydens concludes by saying:

> To teach rhetoric well in technical contexts is to humanize the making of scientific and engineering knowledge and material artifacts, to work toward an ideal of engineers who can learn to communicate effectively in any activity

> system, especially in high-stakes situations, and to work toward an ideal of engineers whose curriculum allows them to be and to enact more fully integrated selves. (p. 261)

Leydens' comments reflect the US college context, where writing instruction, including rhetorical writing, is part of university study. However, writing practices are not embedded in the engineering curriculum; Leydens also notes that the disciplinary ideology of engineering courses devalues writing in engineering studies (p. 244).

An Australian context for engineering faculty perspectives of writing is provided by Howard, Khosronejad and Calvo (2016), who examined engineering educators' views about writing and online writing tools to support the development of engineering students' communication capabilities in undergraduate subjects. The study was part of a larger project examining undergraduate engineering teaching in three Australian universities. The authors used the repertory grid theory method to elicit engineering educators' perceptions of writing 'as an assessment type and in relation to three other types of assessments' (2016, p. 4), and the extent to which they saw online writing tools as useful; the participants in their study perceived written assessments to be more useful than multiple-choice exams, oral presentations and projects (which they define as the creation of a product). At the same time, the participants regarded projects as a more useful way of assessing students' depth of understanding than written assessments. The authors conclude that there are a range of views about writing as an assessment task, and that engineering educators are generally not aware of online writing tools to provide support for students. However, the authors do not provide clarification of what is meant by online writing tools, nor is it clear whether the participants were asked if they were aware of the range of online writing tools available, and how they might be used. This study is interesting, but also somewhat confusing in the way that forms of assessment have been disaggregated. Engineering projects usually involve writing as part of the project – a project report or an oral presentation and report, all of which count towards the assessment. A drawback of the methods of this research is that because it focuses on writing as an assessment type, it does not capture participants' perceptions of writing as a practice. This is partly due to the constraints imposed on the interpretation of the data by relying on the repertory grid theory to identify engineering educators' perceptions of writing. Overall, the study contributes to an understanding of engineering educators' perspectives of writing in the curriculum, but leaves many questions still to be asked, such as how engineering educators see writing practised in the curriculum, and how they see writing practices being developed.

2.2 What is meant by 'the invisibility' of writing practices?

At the beginning of this chapter reference is made to the marginalisation of writing practices in higher education both for students (Curry & Lillis 2003) and for academics (Murray 2013). In this section I build on this notion to suggest that academic writing practices are generally invisible, as argued by Curry and Lillis in the context of student writing in higher education:

> Student academic writing continues to be at the centre of teaching and learning in higher education, but is often an invisible dimension of the curriculum; that is, the rules or conventions governing what counts as academic writing are often assumed to be part of the 'common sense' knowledge students have and are thus not specifically taught within disciplinary courses. (2003, p. 3)

Similar points are made by Mitchell (2010) in arguing that writing in higher education 'has suffered a kind of invisibility' (Mitchell 2010, p. 135); it is hidden physically (writing experts tend to be placed in obscure corners of university campuses) and epistemologically, through the separation of content from writing, and through writing being viewed as a generic skill. Along with the assumption of academic writing practices as common knowledge is the perception that students who do not have this knowledge will osmotically acquire it along with their disciplinary knowledge (Curry & Lillis 2003, p. 3). A related point is made by Murray regarding the writing practices of academics: 'while institutions may require academics to produce written outputs of a high standard and in specific numbers, the act of writing is neither defined nor accounted for in academic workplaces and workloads' (Murray 2013, p. 87). In neither the curriculum nor in academic workloads is there provision for the practices of writing: for the time it takes to write, seek feedback and revise, nor for the acquisition and development of the disciplinary discourses of writing that students and academics are expected to master. Thus one aspect of the invisibility of writing practices is the assumption, linked to the view of writing as a 'study skill', that students will already have the requisite knowledge about writing at university and in their discipline. This links to Murray's point regarding the 'act of writing' for academics, and perhaps reflects the idea, still prevalent in technical disciplines, of 'writing up' one's research. The 'write-up' is regarded as a perfunctory, clerical activity in contrast to the complexities of conducting 'research'. The view of writing as a clerical activity in the engineering context is discussed in more detail in Chapter 5 (the otherness of writing in the engineering curriculum).

Another aspect of the invisibility of writing practices is that of transparency. Turner (1999) argues that academic literacy has been 'occluded in a "discourse of transparency"' (p. 149), and that language is expected to be a neutral carrier of meaning. This expectation assumes that 'students learn a neutral, transparent medium in order to learn an epistemologically transparent message' (p. 158). When language is working well it is invisible or transparent – it is only when it breaks down that it becomes visible. Furthermore, because language use in academic discourse is associated with rationality and logic, if the language is used incorrectly it indicates a failure in the user's logic and rationality (1999, p. 150). This can often be a means of demonstrating that 'non-traditional' or 'first generation' students at university are somehow not up to university standard if they do not have command over the academic discourses required of them.

Thus writing practices are for the most part invisible in higher education for the following reasons: firstly, they are often assumed to be part of common sense knowledge. They are invisible because language is generally regarded by the academy as a transparent vehicle for communication: 'the great utopia of a perfectly transparent language in which things themselves could be named without any penumbra of confusion' (Foucault 1970, cited in Turner 2011, p. 28). They are invisible because space – physical, temporal or cultural – is rarely provided for the development of writing practices within the mainstream curriculum. They become visible only as 'study skills' in the 'deficit model' of remediating students whose writing skills are seen as lacking. The following section discusses what is meant by the invisibility of writing practices with specific reference to the engineering curriculum.

2.2.1 What is meant by 'the invisibility' of writing practices in the engineering curriculum?

I started using the term 'the invisibility of writing practices in the engineering curriculum' because it became clear during the course of this research that writing practices are often present in the engineering curriculum in isolated examples, such as in engineering design subjects where students are expected to write a project report, or in subjects that require lab reports. However, they can be difficult to find throughout an engineering degree program or course; there is rarely a sense that writing practices are seen to be developmental, as noted by Yalvac and colleagues in their evaluation of approaches to integrating higher order writing tasks into an engineering subject in an American university:

> Even those faculty members who appreciate the merit of offering writing in content areas may be reluctant to add writing exercises because of the additional work such exercises entail. Many faculty members are also concerned about what they might have to remove from a course to make room for a writing exercise. In addition, some engineering faculty may be unconvinced about the effectiveness of integrating writing instruction into their classes. (Yalvac et al. 2007, p. 118)

The situation encapsulated by Yalvac and colleagues' comments is fairly representative of engineering faculties in Australia and the US. In fact, the *practice* of writing practices is one of the key areas of invisibility. For example, an analysis of subjects in first year engineering at two Australian universities in a major metropolitan area shows that there is no writing excluding notation required by the students for six of the eight subjects (University 1) and for seven of the eight subjects (University 2). Up to 90% of the assessment in the subjects 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 (Goldsmith, Willey & Boud 2012). When students are required to write as part of their assessment, opportunities are rarely provided for them to practise writing without being assessed.

Furthermore, writing as a developmental practice is hard to detect. Students may be asked to write reports in their first year studies and again in their third year studies, but there is no guarantee that the quality of reports written by third year students would be higher than those written by first year students. This contrasts with the hierarchical and increasingly complex propositional knowledge acquired by engineering students throughout their courses; all members of particular engineering disciplines will be aware of the nature and level of the knowledge that students should be learning in each year of the course.

In addition, the continued presence of writing practices within a subject or a course is not guaranteed; an increase in enrolment numbers, a change in teaching staff, changes in assessment requirements can all have a swift and lasting impact on the type, word length and quantity of written assignments that students are required to submit. Thus what used to be a flagship subject, or series of subjects that developed students' writing practices in a sequential manner, may change from one year to the next because the pressure of marking and providing feedback on written assignments to 50 students may become intolerable if student numbers increase to 150, 200 or 300. Changes such as dropping the number of required reports from four to two or one, or of reducing the length of the assignment, or of reducing the weighting of the marks given to written assignments, can cause writing practices to become fragmented, and for their development to become incoherent.

Previous research on engineering students' writing practices, particularly the work that has focused on interventions to help students write, reveals that these interventions are ephemeral, and unlikely to remain (e.g. Carter, Ferzli & Wiebe 2007; Fischer 2015; Garland, Duerden, Helfers & Evans 1999; Herrington 1985; Shapiro 1991). Writing practices do not disappear completely, but they are constantly under siege: when enrolments increase or teaching budgets are reduced, writing practices are the first to be cut and the last to be reinstated. Engineers need to write, and need to practise writing, but making these practices visible, sustainable and developmental seems to require more than just a mandate that engineering graduates need strong written and communication skills. The prevailing perceptions of writing as separate from propositional knowledge, of writing being a skill rather than a practice, and of the responsibility for the development of writing practices being someone else's problem all conspire to render and keep writing practices invisible in the engineering curriculum. The following section outlines the types of knowledge that are highly visible in the engineering curriculum as a way of understanding more deeply why writing practices remain invisible.

2.3 Types of knowledge in the engineering curriculum

The current delivery of the engineering curriculum in the majority of Australian universities, anchored as it still is in engineering science, reflects a positivist epistemology (Radcliffe 2006) which values propositional knowledge – knowing about things, or 'knowing what' (Biggs & Tang 2007, p. 73). 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 epistemology and pedagogy outlined above create a range of outcomes, including learning for reproduction (Beswick & Ramsden 1987) and learners as passive recipients of the knowledge transmitted by their teachers (Samuelowicz & Bain 2001). The acquisition of this knowledge is measured by how well students can reproduce it under exam conditions; this has significant impacts on how students learn and what they learn.

Firstly, it inadvertently encourages surface approaches to learning, indicated by a focus on memorising information and associating facts and concepts unreflectively (Biggs & Tang 2007) 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:

> … while undertaking the exam often highlights to students their learning deficiencies, it typically has no impact on their learning as they rarely receive feedback other than a mark or grade and there is no further opportunity to address these learning gaps. (Willey & Gardner 2012, p. 2)

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). The majority of examinations require students to answer a limited range of questions, usually on well-structured problems, under strict time pressure. As Nightingale, Carew and Fung (2007) point out, there is little scope for this style of examination to test the broader range of graduate attributes expected by employers and by Engineers Australia.

A deeper implication of the emphasis on knowledge acquisition assessed by formal examinations is that it denies the perspective that learning is ‘socially and culturally constructed’ (Boud 1993) and that it is constructed by the learner; instead, the focus is on the transmission of knowledge from the knowledgeable lecturer to the ignorant students. This in turn creates a relationship where the lecturer holds the power and is in a dominant position; students are then constructed as docile and passive recipients of knowledge (Lee & Taylor 1996). It is necessary for engineering students to acquire propositional knowledge and to know how to apply it; however, it is also important for them to be able to explain what they are doing – communication of concepts can deepen understanding (e.g. Artemeva 2011; Carter, Ferzli & Wiebe 2007). Reproduction of knowledge for short-answer exams does not always provide the intellectual or linguistic resources to frame questions which might provide alternative ways of solving problems, or which consider a variety of contexts for applications of knowledge.

A study of engineering educators’ attitudes to teaching and learning in four Australian universities as part of an Australian Learning & Teaching Council (ALTC) project on reforming engineering education (Goldsmith er al. 2010) found that lecturers teaching the ‘engineering science’ subjects – thermodynamics, fluid mechanics and solid mechanics (Lucena 2003, p. 421) – designed their units of study to have individual assessment tasks which were heavily weighted towards tests and final examinations. These subjects also privileged technical content, with the EA competencies (based on the 2008 version) of knowledge and skill base being much more valued in the learning outcomes than engineering ability or professional attributes, as is demonstrated in Table 2.3. As part of the study, 16 engineering lecturers were interviewed across four Australian universities; Table 2.3 categorises their responses to the question ‘what are the most important things that students learn in your unit?’ into the three EA Stage One competencies.

Table 2.3: Responses to ‘What are the most important things that students learn in your unit?’ (Goldsmith et al. 2010, p. 3)

Strand/No. of lecturers	PE 1 knowledge & skill base	PE 2 engineering application ability	PE3 professional & personal attributes
Engineering Design (4)	1	13	9
Engineering Science (12)	15	1	1

In the Engineering Science strand, the model is that of the traditional lecture/tutorial structure. Even where there are demonstrations, in the majority of subjects the students are expected to observe passively, or at most note down the calculations. When asked the question ‘what is the best way of measuring student learning in your unit?’, the responses included the following:

Table 2.4: Lecturer responses to: what is the best way of measuring student learning in your unit? (Goldsmith, Reidsema, Beck & Campbell, 2010)

Engineering Science (12)
Progress tests; e-learning exercise; final exam (measures individual learning); mid-session exam; (not assignments because students would copy from each other); (not labs) the final marks; during class (students asking questions); lab reports; producing the artefacts for testing.

The responses here demonstrate not only a preference for tests and exams, but a mistrust of assignments where ‘students would copy from each other’, again illustrating the belief that the *only* way to see if a student has learned something is by an exam because it ‘measures individual learning’. Such a belief reflects what engineering educators understand engineering to be: the application of technical knowledge to scientific problems, reflecting the dominance of the engineering science curriculum. These findings are supported by research in engineering education internationally (e.g. Pawley 2009; Sheppard et al. 2009) and in Australia (e.g. King 2008; Male, Bush & Chapman 2009; Trevelyan 2012). Trevelyan (2012) argues that ‘[b]uilding students’ capacity for solitary technical problem-solving remains the central objective of engineering education’ (2012, p. 4).

An emphasis on knowledge that can be tested by a limited range of questions devalues writing practices, both the capability to communicate in writing, and the learning that comes from writing practices. If a subject that has been taught over 14 weeks can be assessed in a one-hour quiz and a three-hour final examination, both consisting of questions that test calculations and the memorising of formulae, the message that this assessment communicates is at least two-fold. Firstly, learning is demonstrated by knowledge that can be reproduced for exam conditions; secondly, writing practices have little or no place in the learning of engineering knowledge.

The separation of knowledge from language has been explored by Brown, Reveles and Kelly (2005) in their work on the construct of discursive identity, investigating ‘the potential co-construction of student identity and scientific literacy’ (2005, p. 779) in science education. Within the context of scientific literacy, the authors present two central perspectives: a *knowledge-centred perspective* that sees value in the development of students’ scientific knowledge and practices for the purpose of them becoming scientists. This is in contrast to, but not exclusive of, a *sociocultural-centred perspective* that situates any definition of scientific literacy in everyday activities and looks at the relationship between literacy, activities and the social context (2005, p. 780). Where these two perspectives differ is in the way that language is conceptualised; this conceptualisation connects to Turner's argument (1999, 2011) that language in the academy is seen as a neutral carrier of meaning and to views of engineering knowledge versus writing practices. A knowledge-centred perspective regards language as a means of transmitting knowledge, and presumably as value-free, whereas a sociocultural-centred perspective sees language as central to constructing interactions, and that scientific literacy is therefore constructed through the use of language (Brown, Reveles & Kelly 2005, p. 780). These two perspectives echo the epistemological spectrum of beliefs outlined by Samuelowicz and Bain (2002) from positivist to constructionist, and the perspective of situated learning (Brown, Collins & Duguid 1989). The separation of knowledge and language can also be explained in part through legitimation code theory (LCT), which can assist in understanding differences in how knowledge is viewed, for example in engineering as compared to the social sciences.

Legitimation code theory is an evolution from Bernstein's work on knowledge codes (e.g. Bernstein 2000). Bernstein defines two principal educational knowledge codes: a collection code, where knowledge is hierarchical and builds on what has gone before, and an integrated code where knowledge is segmented and relies on the insight or 'gaze' of the knower (Maton 2010). Maton and colleagues (e.g. Maton 2000, 2010; Muller 2008; Muller 2009; Winberg et al. 2016; 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: knowledge code, knower code, elitist code and relativist code. 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 p. 87). 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. An elitist code is one that has strong epistemic relations and social relations, such as is found in practitioners of the study of music. A relativist code has weak epistemic relations and weak social relations, 'where anything goes' (Maton & Chen in press).

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 the subject of secondary school English is regarded as predominantly a knower code (Jackson 2016; Martin & Maton 2013). The lens of LCT illuminates the epistemological beliefs of members of different disciplines, and suggests why people from an engineering background can struggle to see knowledge about writing as a valid epistemology. The hierarchical view of knowledge is demonstrated in the structure of the engineering curriculum, where certain subjects are pre-requisite for more advanced study; there are foundational concepts which must be mastered before students can progress to more complex concepts. Such a knowledge-centred perspective valorises propositional knowledge and sees language as a neutral means of transmitting propositional knowledge, not as a kind of knowledge with which faculty staff and students can interact in order to co-construct an understanding of engineering. The prevalence of this approach impacts both the perspectives and the teaching and learning practices of engineering educators in terms of how or whether they see writing practices within the engineering curriculum. By regarding language as a neutral medium for 'encoding and decoding' information, writing is stripped of the capacity to be a practice. Alternatively, writing can be seen as such a different kind of knowledge that it is outside the domain of engineering; it is effectively othered, as explored further in Chapter 5 of this thesis.

Whether writing is seen as a transparent medium of communicating ideas, or as belonging to a different code of knowledge, the net effect in many engineering curricula is for writing practices to be invisible. If they remain invisible, they will remain both unpractised and undeveloped. This not only impacts engineering students' writing proficiency, it also impacts how they learn, and can influence how much they retain and understand of what they learn, as argued by Carter, Ferzli and Wiebe (2007) and others.

In order to investigate engineering educators' perspectives of writing practices in the engineering curriculum, it is important to consider the interplay between the engineering educators' practices within the local context of their own subject and within the larger context of the engineering curriculum, set in the landscape of Australian higher education. The situated nature of teaching and learning practices and of individuals' perspectives requires a lens that can capture this interplay, while acknowledging the agency of the individual and constraints and enablements of the curriculum. Practice theory can provide both a theoretical lens with which to understand more deeply the nature of such practices and a methodological approach to analyse the practices. The following section discusses practice theory perspectives, including activity theory and Schatzki's practice theory, with a focus on the theory of practice architectures as the theoretical framework for the research presented in this thesis.

2.4 Practice theory perspectives

Practice theory has emerged from several different theorists – Bourdieu, Giddens, Kemmis, Reckwitz, Schatzki and Shove – underpinned by the thinking of Heidegger and Wittgenstein (Schatzki 2012, p. 13). The term 'practice theory perspectives' is used to acknowledge that there are various approaches taken to theorise practice which have emerged from different research streams. There are thus notable differences as each practice-based approach 'has its own history, vocabulary, and set of basic assumptions' (Nicolini 2012, p. 9). Nevertheless, Nicolini has identified several shared 'family resemblances' (2012, p. 9) amongst practice theory perspectives, and claims that a practice-based approach:

> …Forces us to rethink the role of agents and individuals, e.g. managers, the managed etc.

> Foregrounds the importance of the body and objects in social affairs.
>
> Sheds new light on the nature of knowledge and discourse.
>
> Reaffirms the centrality of interests and power in everything we do. (Nicolini 2012, p. 6)

In the introduction to his book on practice theory Nicolini argues that '[t]he contribution of a practice approach is to uncover that behind all the apparently durable features of our world there is always the work and effort of someone' (2012, p. 3). Practice theory perspectives work to uncover '[d]eeply embedded beliefs and taken-for-granted discourses' (Salamon et al. 2014, p. 1) which underlie many practices. Uncovering these practices and making them more visible can provide opportunities to challenge or rethink practices that are unhelpful or damaging. The emphasis on practices rather than on practitioners can allow a new way of looking at the elements of a practice, and can shift the focus away from individual practitioners while still acknowledging their agency. Having practice as the unit of analysis acknowledges the situatedness of practices – that they belong to a particular place and time, and unfold in ways that are shaped by specific conditions (Kemmis et al. 2014, p. 33) or arrangements (Schatzki 2012, p. 19). Furthermore, 'practices...entwine people, technologies, spaces, time and artifacts' (Rooney et al. 2012), so the analysis of a practice involves developing an understanding of complex interactions of these arrangements. As Boud and Brew cogently point out, practice is co-constructed: 'Discussion of practice in isolation from practitioners or sites of practice is to misunderstand the nature of practice' (2017, p. 81). Thus, focusing on the practice allows researchers to consider the interactions of objects, organisations, people, processes, relationships, rules and specific situations when developing an understanding of dynamic practices.

Practice theory perspectives allow researchers to conduct social investigations to gain a deep understanding of complex phenomena such as higher education. Manidis and Yasukawa make the claim that 'a practice-based perspective goes beyond mere descriptions of actions … and describes instead "the creation of meaning, identity formation, and ordering of activities produced" (de Souza Bispo 2015, p. 314) *in and beyond* the classroom' (Manidis & Yasukawa 2017, p. 108; emphasis in the original).

The research presented in this thesis is investigating academics' perspectives of writing practices in the engineering curriculum. Writing practices are often difficult to locate or are invisible. Thus a lens is needed that can uncover what usually remains out of view, or is hidden in plain sight. It needs to focus on the interplay between the social and the individual within the context of the academics' teaching practices in their engineering subjects, as each site of practice has its own local conditions, but is also set within a larger landscape. As Reckwitz argues, '...discursive formations are just social practices, neither more nor less; they are practices of representation in which objects in the world are represented, imagined, and evaluated, with the aid of media technologies' (2017, p. 122). Thus, practice theory provides a highly appropriate perspective with which to explore the 'discursive formations' of writing practices and how they are understood in the engineering curriculum.

The elements of practice theory perspectives combine to form a powerful way of investigating how engineering educators view writing practices within the engineering curriculum and within the context of the engineering subjects that they teach. The richness that a practice-based perspective provides for describing and accounting for the frequently unexamined practices and arrangements of engineering educators' teaching and learning has thus led me to adopt this approach in the analysis of the data presented in this thesis.

In this discussion of practice-based approaches, it is useful to understand what is meant by 'practice'. Nicolini argues that just as there is no unified or grand theory of practice, there is no one definition of practice (2012, p. 9). Green makes the point that '[practice] is a term that circulates incessantly, and seems constantly and even compulsively in use, without always meaning much at all' (2009, p. 2) but he provides the following useful explanation: 'a practice…occurs in time and space and is thus necessarily situated, and …always involves both (re)production and renewal, or transformation' (2009, p. 12). Rooney and colleagues' definition of a practice as being embodied, materially mediated, relational, situated and emergent (Rooney et al. 2015) provides an understanding of how a practice interacts with its environment and must be considered within its local context – the site of the local. Schatzki sees practices as 'organized activities', while Mahon et al. (2017) explain a practice in the context of practice architectures theory as follows: '

> A practice is understood as a socially established cooperative human activity involving utterances and forms of understandings (sayings), modes of action (doings) and ways in which people relate to each other (relatings) that 'hang together' in characteristic ways in a distinctive 'project'. (2017, p. 8)

The project of a practice is its intended outcome and the actions undertaken by the practitioner to achieve the outcome, whether or not the outcome is attained. The research in this thesis is informed by these perspectives of a practice, initially through the lens of activity theory, but predominantly in regard to the proponents of practice architectures theory.

2.4.1 Activity theory

The initial data analysis for this research was conducted using activity theory, which originated from Vygotsky's and Leont'ev's work in early 20th century Russia, and since the 1960s has been used to explore learning in educational and in workplace contexts (Engeström 2001; Jonassen & Rohrer-Murphy 1999). It regards learning as culturally, socially and historically situated, so that there is no Cartesian mind/body divide; learning takes place within a social context. Because of its situated nature, activity theory (AT) allows researchers to explore 'the wider social and cultural contexts that are grounded in the history of [a] particular professional practice' (Orland-Barak & Becher 2011, p. 116). It also reveals internal contradictions in practices, which can be overlooked when people focus on individual process and textual products (Dias et al. 1999, p. 28). AT analysis examines these activities in the framework of an activity system. Each system comprises subjects (the actors performing activities), objects (of activities: artefacts produced, goals achieved), outcomes of objects (such as longer term goals), mediating tools that are used to carry out the activity (writing, computers, documents), the community in which the activity takes place (a faculty, a class, a university), the rules and norms that surround the activity (assessment regulations, course requirements) and the division of labour (who does what, such as who produces the assessment item, who marks it).

A key characteristic of any activity system is the occurrence of internal contradictions, which are also seen as tensions among the elements of the system. These tensions can generate disturbances, but can also bring about innovations. An example of such a tension might be in an activity system of an engineering subject where assessment tasks include a report worth 5% and an exam worth 60%; this leads to a contradiction in how students allocate time and effort to the two tasks (element of division of labour) and how they view the relevance of the two tasks to their learning (element of learning outcomes of the subject). Awareness of these conflicts can spur subject coordinators or curriculum designers to consider different types or weightings of assessment tasks.

Activity theory was a very useful tool with which to begin to analyse the data, as it highlighted tensions within the activity systems of the research participants, causing me to examine these tensions more closely. However, it became clear that not all the questions emerging from the analysis could be answered using this approach. I found that I could not answer how prevailing practices in the engineering curriculum constrain the development of writing practices, and how certain practices can enable the development of writing practices. I then used the theory of practice architectures, which provides a theoretical and methodological perspective 'to explore the ways that practices develop and are held in place both in terms of the agency and actions of individuals, and in terms of the cultural-discursive, material-economic and social-political enabling preconditions that make these practices possible' (Kemmis et al. 2014, p. 15). The particular edge that practice architectures theory provides when investigating academics' practices in higher education is illustrated in the following comment:

> As an attempt to capture the complexity of actual practices – in this case, academics' perceptions of their teaching practices – the concept of practice architectures is a useful vehicle to better understand how specific practices are

> conditioned by their circumstances, as well as contributing to these circumstances. (Hardy 2010, p. 402)

Hardy points out the need to understand the particular context in which practices exist, and how certain practices influence and are influenced by their context. Practice architectures theory is discussed in more detail in the following paragraphs.

2.4.2 Practice Architectures Theory

Schatzki (2012) suggests that at the base of practices are those 'doings and sayings' that can be described as basic activities, which are often physical activities such as writing. These basic activities are attached to further activities, such as taking lecture notes and to 'higher level' purposeful activities or teleological action hierarchies, such as developing notes and resources for a subject studied in higher education. Practices are organised by practical rules (explicit instructions or directives), understandings (that is how to do the actions through 'doings and sayings'), teleoaffective structures ('how they should be carried out' (Nicolini 2012, p. 166)), and general understandings of the significance of a practice (abstract worth or value inscribed in the 'doings and sayings') (Schatzki 2012). Kemmis and colleagues have added the dimension of relatings to sayings and doings to ensure that the relationality of practices is made visible:

> We add 'relatings' to Schatzki's sayings and doings because both doings and sayings necessarily imply relationships between persons and between persons and other objects. We want to make it more explicit that practices are practices because they involve characteristic relationships of 'orchestration' between people and between people and objects. (Kemmis et al. 2012, p. 35)

Kemmis and colleagues (Kemmis & Grootenboer 2008; Kemmis & Mutton 2012; Kemmis et al. 2014) have developed the Schatzkian concept of arrangements further into 'practice architectures', the arrangements that prefigure and shape the conduct of practices. These concepts have evolved into practice architectures theory (PAT), which can be used as a theoretical and as a methodological resource to understand complex phenomena such as professional learning (Kemmis et al. 2014), curriculum renewal

(Goodyear, Casey & Kirk 2016) and team and project work in engineering practices (Buch & Andersen 2015). 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 order to disrupt unfruitful practices, or to effect change, it is necessary to understand first how such practices have come about. As previously mentioned, practice theory perspectives can assist in uncovering the unspoken narratives that run beneath 'the apparently durable features of our world' (Nicolini 2012, p. 6).

Schatzki's practice theory, PAT and AT are all practice theories which regard practices ontologically, so 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 (Schatzki 2002). A practice needs to be understood within its particular spatial and temporal location, which shapes and is shaped by it. This contrasts with practice theories that treat practices epistemologically, where the focus is on the process of coming to know, and on practical knowledge (Mahon et al. 2017, pp. 5-6). The focus on sites of practice is extremely relevant for my research, as the practices within each site – the subjects taught by the engineering educators who have participated in this study – are shaped by their specific circumstances, while at the same time reflecting practices that prevail in the Australian engineering curriculum. By understanding the local conditions which shape and are shaped by the practices within sites of practice, I can uncover the practices and make them visible and intelligible to the practitioners and to the wider engineering education community.

PAT can be used as a theoretical resource, an analytical resource and a transformational resource (Mahon et al. 2017, p. 2); it allows researchers to see the nature of the research problem, the findings and possible ways through the problem in a different way. 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 arrangement 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:

> . ...in these three dimensions, cultural-discursive, material-economic and social political arrangements do not occur separately from one another; they are always bundled together in practice and in places. Bundled together, they give social life – and our consciousness of it – its apparent solidity, its palpability, its reality and its actuality. (Kemmis et al. 2014, p. 6)

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 expert 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. Practices can also interact with other practices to form ecologies of practices, as discussed in the following section.

2.4.3 Ecologies of practices

The theory of ecologies of practices has emerged from research on practice theory and practice architectures conducted by Stephen Kemmis and colleagues since 2008, and can be seen as a sub-theory of practice architectures theory. Kemmis defines ecologies of practices as:

> Distinctive interconnected webs of human social activities (characteristic arrangements of sayings, doings and relatings) that are mutually necessary to order and sustain a practice as a practice of a particular kind and complexity (for example, a progressive educational practice). (Kemmis et al. 2014, p. 50)

The theory of ecologies of practices posits that practices, like biological systems, can form interrelationships, and that one practice can form the practice architectures for other practices (Kemmis et al. 2014). The theory addresses the ways in which one practice, such as teaching, is influenced by other practices operating at the site such as learning and communicating (Kemmis et al. 2012). The lens of ecologies of practices can enable the researcher to see how practices influence one another, thus providing a deeper understanding of the interrelatedness of practices within a site of practice and in the practice landscape in which that site is located. Practice landscapes are the settings 'where multiple kinds of different practices occur, and in which there may be multiple and overlapping sites of practice' (Mahon et al. 2017, p. 25).

Kemmis et al. (2014, p. 50) note that 'practices can sustain…or suffocate other practices, and different ecologies of practices may be hospitable to some practices and not to others'. An exemplar of ecologies of practices is the Education Complex, where five different kinds of educational practices interrelate and which form an ecology (see Figure 2.3 below): educational research and evaluation; professional development/learning; educational leadership and administration; teachers' classroom educational practice (teaching); students' academic and social practices (learning). This illustrates 'the empirically observable relationships of reciprocity, complementarity and mutual support that sometimes (not always, and contingently) exist in practice…between particular species of the five different kinds of educational practices in the Education Complex in particular sites' (Edwards-Groves & Kemmis 2015, p. 15).

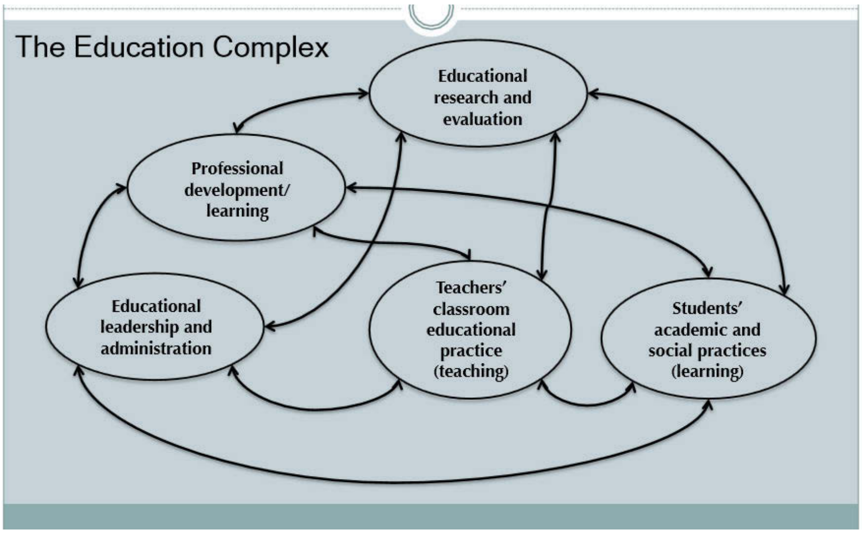

Figure 2.2: The Education Complex (http://ips.gu.se/digitalAssets/1467/1467159_kemmis-pep-theory-Tromsø.pdf)

The arrows show the connections between and among practices within the Education Complex; these interactions and the arrangements that prefigure them work to constrain and enable the practices captured in the diagram. Edwards-Groves and Kemmis argue that:

> …different, lived and living practices sometimes form relationships of interdependence with one another in ecologies of practices, nudging against one another as they unfold (not always harmoniously, and not always in relation to all of the others). (2015, p. 15)

Viewing sites of practices through the lens of ecologies of practices can reveal how practices are connected, how they relate to and influence one another, and the conditions that allow some practices to flourish while other practices wither or languish. In this study, the theory of ecologies of practices has been applied to the analysis of the case studies to understand how prevailing conditions in the Australian engineering curriculum generally do not provide an environment where writing practices can prosper.

2.5 Conclusion

This chapter has provided an overview of the key issues that relate to the research problem, and the approach used to explore the research questions. It identified perspectives of writing in higher education and outlined the perspective of writing used in this thesis, which is a combination of the genre discourse and writing as a social practice. These perspectives see writing as a practice and provide opportunities for disciplinary academics to provide models of the text types they are asking their students to produce. This chapter established what is meant by writing practices, both in the context of higher education and more specifically within the engineering curriculum, and has discussed perspectives of the invisibility of writing practices and how they are used in this research. The chapter then identified types of knowledge that are privileged in the prevailing engineering curriculum in Australia and the impact this has on the development of writing practices. The fourth section gave a brief overview of practice theories and how they can be applied to investigating writing practices within the engineering curriculum, and argued that practice architectures theory is an appropriate theoretical framework through which to view the research questions and with which to analyse the data in this research. In the following chapter I introduce the methodological framework for the research and explain the approaches to data collection, analysis and interpretation.

Chapter 3
Methodology

Overview

Chapter 1 introduced the wider context of writing in the engineering curriculum; Chapter 2 outlined the key theoretical perspectives in which my research is based, suggesting that the perspectives of engineering educators towards writing practices in the engineering curriculum have been under-researched. Chapter 2 argues that if writing practices remain invisible, they will remain both under-practised and underdeveloped. This will not only impact engineering students’ and graduates’ writing proficiency; it will also impact how they learn, and can influence how much they retain and understand of what they learn. Therefore, uncovering the unspoken narratives around why writing practices are invisible in the engineering curriculum can allow writing practices to become visible, practised and developed, enabling engineering students to graduate with the high level written communication practices expected of them.

As discussed in Chapter 2, the research presented in this thesis uses practice architectures theory, or PAT, as a theoretical and an analytical framework. This chapter describes the methodological approach and the methods used to investigate the research questions. The chapter begins by briefly sketching the journey to the methodological approach I have used in this research. It then explains the methods used, before introducing the research participants in the study and the ethical considerations involved. It then provides details of data collection. The chapter concludes with an explanation of how the data were analysed.

3.1 Research approach

As explained in Chapter 1, I have spent several years working with engineering educators exploring some of the challenges that face engineering education in an Australian context. I have also spent many years in the field of academic literacies, teaching students, including engineering students, about writing practices in higher education. These sets of experiences have combined to plant the seeds of the research questions being explored in this thesis. From the outset I determined that a qualitative approach would be suitable for investigating these questions, as qualitative research emphasises understanding and explaining complex phenomena. By studying the context in which activities occur, the researcher can develop a multi-layered picture of the subject being studied (Denzin & Lincoln 2005). As I sought to explore people's perceptions, understandings and experiences in specific contexts, a qualitative methodology was necessary, to answer questions of how and why, and to provide understanding of a context for participants within that context.

The initial investigation was on engineering educators' perceptions of writing in the engineering curriculum, so I began by considering methodological approaches with an applied linguistics or academic literacies angle, including linguistic ethnography, as a way of exploring the relationship between engineers and the discourse of engineering, and the relationship between context and text (Blommaert 2007; Creese 2008; Lillis 2008).

> Linguistic ethnography generally holds that, to a considerable degree, language and the social world are mutually shaping, and that close analysis of situated language use can provide both fundamental and distinctive insights into the mechanisms and dynamics of social and cultural production in everyday activity. (Rampton et al. 2004, cited in Lillis 2008, p. 375)

However, as the research question became more refined and there was a shift from a linguistic focus to the practices of teaching and learning writing within the research participants' engineering subjects, it became clear that a methodology was needed to explore the situated nature of these practices, and to frame teaching and learning practices as central to the research. As discussed in Chapter 2, this led to consideration of practice theory perspectives. Practice theories '... assert that we know more than we can say, they also assert that what we do typically means more than we know' (Mahon et al. 2017, p. 5). Chapter 2 includes a brief account of how the data were initially analysed using activity theory (Engeström 2001; Jonassen & Rohrer-Murphy 1999) and the move towards practice architectures theory as a theoretical and analytical lens which helped me to respond to the research questions more fully. As a brief reminder, the research questions are:

- How are writing practices invisible in the Australian engineering curriculum?
- What are the contributing factors that make them invisible?
- What constrains and enables the development of writing practices as part of learning to become an engineer?

3.1.1 Practice architectures theory as a theoretical perspective

As outlined in the literature review in Chapter 2, the practice theory perspectives of Schatzki and Kemmis and colleagues consider that '[p]ractices are…the basic unit of any analysis of social science and the necessary keystone of any account of social phenomena' (Nicolini 2012, p. 172), and regard practices ontologically, so the focus is on the site of practice. Schatzki makes the following point about site ontologies:

> Site ontologies maintain that social life, by which I mean human coexistence, is inherently tied to a kind of context in which it transpires. The type of context involved — called 'sites' — comprises contexts of which some of what occurs or exists in them are inherently parts…This thesis, in turn, implies that a certain type of context is central to analyzing and explaining social phenomena. (Schatzki 2005, p. 467)

A site of practice is 'that realm or set of phenomena of which it is a part' (Schatzki 2005, cited in Mahon et al. 2017, p. 9), or the temporal-spatial circumstances in which particular practices are enacted for an intended outcome (the 'project' of a practice), whether or not that outcome is achieved. The centrality of a site of practice to analysis means that researchers 'attend to the specific content and conduct of practice, its organisation in space and time, the arrangements that make it possible and hold it in place…' (Mahon et al. 2017, p. 5). Focusing on the temporal-spatial context and the arrangements of a site of practice allows the analysis of interactions between time, space, material artefacts and human participants within that site, and acknowledges the importance of local circumstances. At the same time, from a site ontological perspective, practices are intertwined and one practice can be the site of another practice (Schatzki 2002). In the research presented in this thesis, investigating the sites of practices of the research participants provided the opportunity to analyse the activities within those sites using both a local and a more generalised lens, and to understand that what went on in one site of practice might play out in another site of practice in a different way because of a different context: the 'situated, social and relational' nature of practices (Mahon et al. 2017, p. 5). Sites of practice are located in practice landscapes, the settings 'where multiple kinds of different practices occur, and in which there may be multiple and overlapping sites of practice' (Mahon et al. 2017, p. 25). In this research the practice landscapes are the universities in which each participant works and where their site of practice is located: more specifically, the faculties of engineering in each institution, including the school or discipline of engineering.

Schatzki distinguishes between 'orders' and 'practices' when explaining the interactions or nexus between the two that occur in any site and form the practices which structure and are structured by human existence: Orders are arrangements of entities (e.g. people, artifacts, things), whereas practices are organized activities. Human existence thus transpires as and amid an elaborate, constantly evolving nexus of arranged things and organized activities (Schatzki 2002, p. xi).

Kemmis and colleagues have adopted the term 'arrangements' rather than 'orders', and use 'arrangements' interchangeably with 'practice architectures'. An example of practice architectures interacting with practices in a site of practice would be curriculum documents, such as a subject outline and the institutional policies that underpin it (arrangements), which then constrain and enable certain types of teaching and learning activities (practices) that take place in the engineering subject (the site of practice).

The relationship between arrangements and practices is referred to as bundled (Schatzki 2012) or enmeshed (Kemmis et al. 2014), to reflect the dynamic interactions that take place within a site of practice, as illustrated in Figure 3.1. In PAT the arrangements are termed cultural-discursive arrangements, material-economic arrangements, and social-political arrangements – they are the practice architectures that hold practices in place, and that constrain and enable practices within a site of practice. The elements of a practice are referred to as sayings, doings and relatings. PAT sees the social world as comprising three dimensions of intersubjective spaces, which are the spaces that 'lie between people' (Kemmis et al. 2014, p. 4). These intersubjective spaces are semantic space (in language), physical space-time (in work or activity) and social space (in relationships), which interact with one another (Kemmis et al. 2014, p. 4). Figure 3.1 shows the interconnectedness of practices and the arrangements and dimensions in which they operate from a PAT perspective. It illustrates how each arrangement operates in its own space: cultural-discursive arrangements work in the semantic space, material-economic arrangements operate in the physical space and social-political arrangements function in the social space (Kemmis et al. 2014). Each space overlaps and intersects with other dimensions, with the practices – the sayings, doings and relatings – and the elements of practices that are held in place. The relationship between the practitioner, the practice architectures, the practices and the site of practice is represented in greater detail in Figure 3.2. The arrow represents the project, which is the intended outcome of the practice.

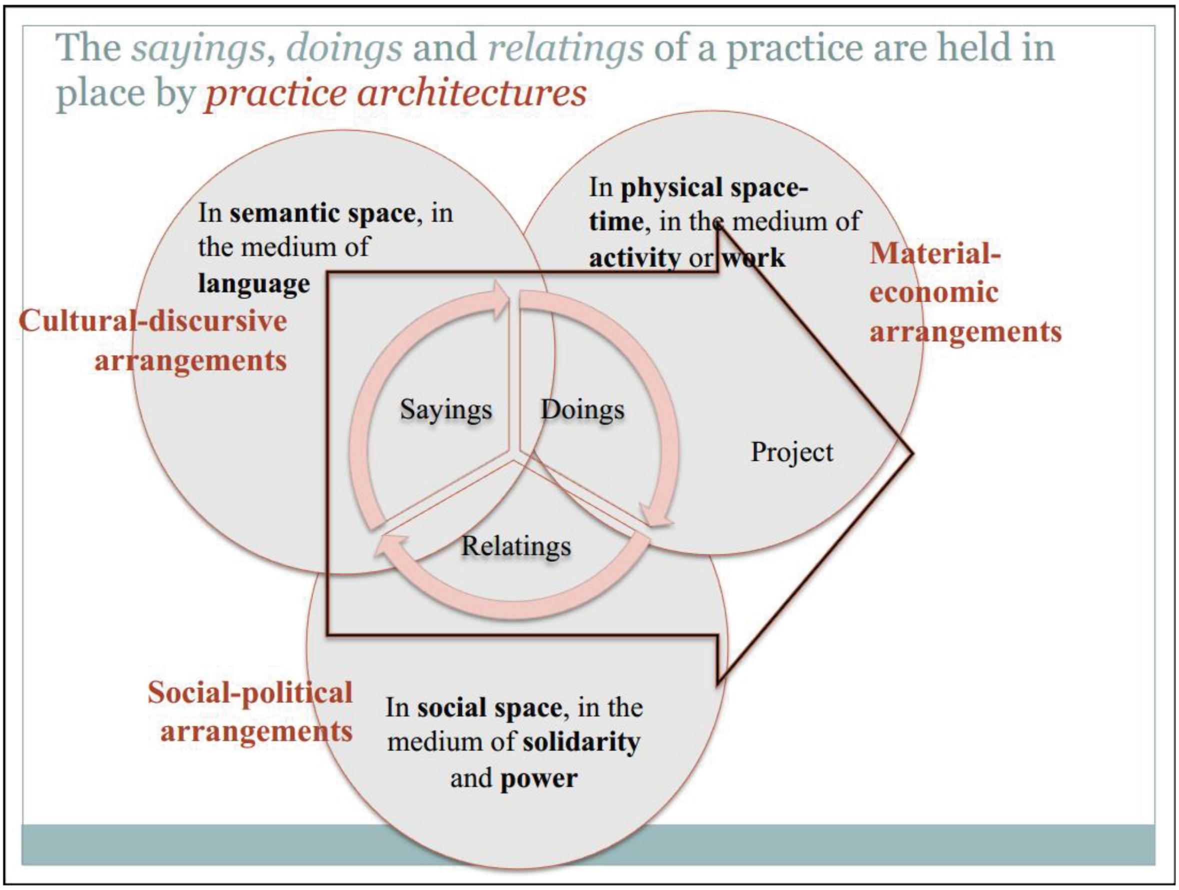

Figure 3.1: Practice architectures (Kemmis 2013, p.3)

An example of practice architectures of writing practices in the engineering curriculum in a particular engineering faculty might be as follows: beliefs held by students and staff such as 'You don't need to be able to write to be an engineer' (cultural-discursive arrangements); assessment tasks that involve little writing (material-economic arrangements); assessment criteria for written assignments that do not include the quality of writing and the 'low status of teaching compared to research in many institutions' (Goodhew 2010, p. 95) (social-political arrangements). All of these arrangements interact with one another not only to constrain the learning of writing practices, but also to enable learning that emphasises the acquisition of knowledge which can be memorised and reproduced under exam conditions.

3.1.2 Practice architectures theory as an analytical perspective

PAT can be used as a perspective to reveal the practices and practice architectures of a site of practice, and to see how they constrain and enable particular practices. It does this by prompting researchers to ask questions that 'identify actual empirical connections between practices and arrangements' (Mahon et al. 2017, p. 19), such as how practices are enacted and why, which practice architectures hold practices in place and how this happens. PAT also stimulates researchers to consider the role of human agency in enacting practices and constructing practice architectures. As Mahon notes, 'practice architectures are neither fixed, nor stable. Rather, they evolve through practitioners' ongoing individual and collective practice and praxis. This, importantly, acknowledges the role of human agency in constructing practice architectures' (Mahon 2014, p. 76). One of the distinctions between the practice theories of Schatzki and Kemmis and theories such as actor network theory is the emphasis placed on human agency by the former (Reich & Hager 2014). Kemmis and colleagues take pains to point out the importance of human agency in PAT, to dispel the idea that the emphasis on practices in PAT is overly deterministic. 'Particular arrangements set up the conditions of possibility for some practices rather than others, but whether a practice will be performed remains a matter of human agency' (Kemmis, Wilkinson & Edwards-Groves 2017, p. 249). However, they also point out that while people construct the world in which they live through their actions, they are also operating within constraints, such as pre-existing circumstances: '[People] make their own history, but they do not make it as they please' (Marx 1852, cited in Kemmis et al. 2017, p. 249); the authors note that some circumstances are so constraining as to make individual agency almost impossible (Kemmis et al. 2017, p. 249).

Importantly, practice architectures and practices need to be considered in concert, not seen as separate strands of analysis. I have been mindful of this in the analysis of the data in this research, and have tried to focus on prevailing practices, overarching narratives and emergent trends rather than whether an arrangement is cultural-discursive, material-economic or social-political. As noted by Mahon and colleagues (2017, p. 19), PAT is an analytical resource, not a prescribed set of methods; thus researchers need to develop their own strategies for working with data while using a practice architectures perspective. The interrelatedness of practitioners, sites of practice, practice architectures and practices is illustrated in Figure 3.2, which shows how the practices and practice architectures are bundled together.

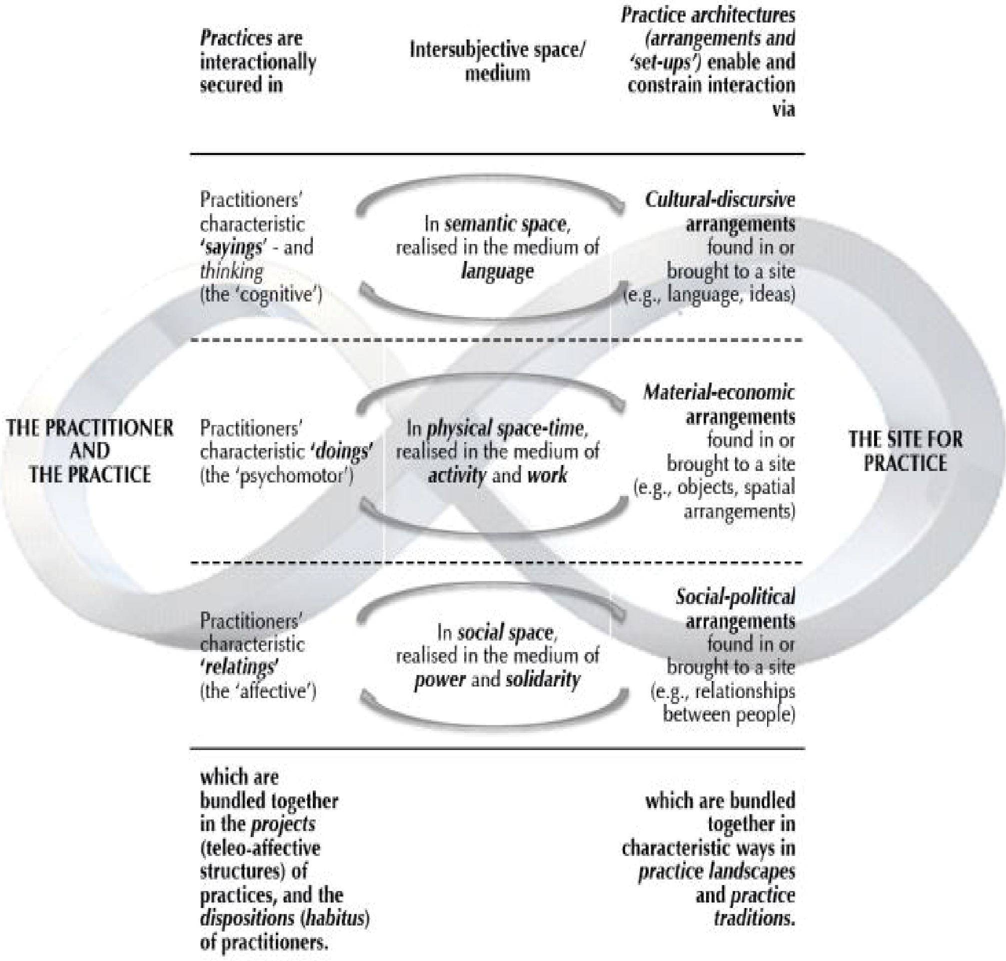

Figure 3.2: Practice architectures theory (Kemmis et al. 2014, p. 38)

Figure 3.2 provides examples of the elements of practices – the sayings, doings and relatings of the practitioner – and of practice architectures, and shows how they are located in their intersubjective spaces in relation to cultural-discursive, material-economic and social-political arrangements. The practice architectures shape and are shaped by the elements of practice and are bundled together in the 'project', or intended outcome of the practice. The interactions of practice architectures with elements of a practice are enmeshed in practice landscapes.

3.2 Case study methodology

As the purpose of my research was to explore engineering educators' perspectives and practices of writing in their teaching, a research strategy that considered the interactions within specific contexts was required; thus a case study approach was chosen. As explained by Eisenhardt: ‘The case study is a research strategy which focuses on understanding the dynamics present within single settings’ (1989, p. 534). Case study methodology is used to examine real world phenomena in specific contexts: it is ‘an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident’ (Yin 2009, p. 18). As the boundaries between practices and practice architectures in my research were not obvious, case study research was a good fit to attempt to understand what was taking place. It emphasises gathering data from a range of sources to create a rich description of the subject being studied: ‘[c]ase studies typically combine data collection methods such as archives, interviews, questionnaires, and observations’ (Eisenhardt 1989, p. 534). For this research, data were gathered using interviews, documents and observations. The data collection methods are explained in more detail in Section 3.4.

Creswell and colleagues identify three different types of case study designs: the single instrumental case study, the collective or multiple-case study and the intrinsic case study. The instrumental case study uses one case to focus on one issue, whereas a multiple-case study selects several case studies to illustrate an issue. An intrinsic case study focuses on the case itself (Creswell et al. 2007, p. 246). In order to study engineering educators’ perspectives of writing practices I used a multiple-case study of engineering educators from several different universities as the most appropriate case study design. An important feature of a case study is that it has boundaries, as pointed out by Creswell et al. (2007): ‘case study research studies an issue explored through one or more cases within a bounded system (i.e., a setting or a context)’ (p. 245). In my research, each research participant became a case study; their site of practice (the engineering subject they taught) formed the boundary of the case study. The question of how many cases is sufficient is one that often arises, as observed by Eisenhardt (1989): ‘ideally, researchers should stop adding cases when theoretical saturation is reached’ (p. 545). This is the principle that I adopted, noting that saturation was occurring after the ninth (research participant) case study was added. To ensure that the approach taken was appropriately rigorous, I developed a research design that incorporated clear research questions and a range of data collection methods. This is described in the following sections.

3.3 Methods

The methods used to explore engineering educators' perspectives of writing practices in the engineering curriculum were appropriate for a case study methodology and were aligned with a practice theory perspective. The following sections outline the recruitment of the research participants and how data were collected from the research sites.

3.3.1 Recruitment of research participants

The research participants were engineering educators employed in a faculty of engineering at five different Australian universities. An initial call for recruitment of participants was made through the Australasian Association of Engineering Education (AAEE) network, which was unsuccessful. I then made contact with colleagues in several Australian universities to make email recruitment announcements on my behalf, and contacted some potential participants directly by email, using networks of connections. Engineering educators who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities were invited to participate in the study; subject coordinators were selected as they have a certain amount of control over the teaching and assessment of their subject. The engineering educators who participated in the study did so voluntarily; thus it can be assumed that they would have had some interest in writing practices in order to have volunteered. This introduces a potential for bias in the sample such that the perspectives of the participants may not be indicative of the wider engineering education community.

3.3.2 The research participants

Table 3.1 provides a snapshot of the research participants and their academic context. Further information is provided in later chapters.

Table 3.1: The research participants

Name	University	Academic level	Industry experience	Engineering discipline	EAL
Adam	A	Assoc. Prof	yes	Civil engineering	No
Bernice	A	Senior Lecturer	yes	Civil engineering	No
Charlie	A	Lecturer	yes	Software engineering	Yes
Damien	B	Assoc. Prof	yes	Integrated engineering	No
Eric	A	Assoc. Prof	no	Electrical engineering	Yes
Felicity	C	Lecturer	yes	Electrical engineering	Yes
Garth	C	Lecturer	yes	Civil engineering	Yes
Harry	D	Senior Lecturer	yes	Electrical engineering	No
Ivan	E	Assoc. Prof	yes	Civil engineering	No

In total, there were nine research participants from four different engineering disciplines in five different metropolitan institutions and from three Australian states/territories. They and their institutions have been de-identified and have been provided with pseudonyms; each participant has been given a name and each institution is identified with a letter. All but one participant was on a continuing appointment:Charlie was on contract which has since been terminated and he is no longer with University A. Eric (University A) had a research-only background; all other participants had at least some years of industry experience after they had completed their university studies, which is a greater representation than would be found in Australian universities, according to Cameron, Reidsema and Hadgraft (2011). A comparison of those with and without industry experience was considered to see if this impacted perceptions of writing practices. Other biographical details of the research participants, such as length of time as an engineering educator or as a researcher in higher education were not part of the data collection, apart from observable demographic characteristics such as gender and language background. As this is a qualitative study, using both case study methodology and PAT, it makes no claims to be representative of the Australian engineering educator community. The participants were selected purely on whether they were engineering educators who coordinated an engineering subject. However, it is interesting to note that two observable demographics of the participants (gender and language background) indicate that they are broadly representative of Australian engineering educators, based on a survey conducted by Cameron and colleagues in 2011. Two out of nine participants are female (22%) compared with 17.2% of females in Cameron, Reidsema & Hadgraft's (2011) survey; four out of nine (44%) have English as an additional language (EAL), whereas 36% of respondents were EAL in the 2011 survey. In terms of engineering disciplines in this study, four participants were from civil engineering, three were from electrical engineering, and one each was from integrated engineering[1] and software. No comparable data were available from the 2011 study.

I knew three participants from either my previous involvement in engineering education projects (Bernice and Ivan) or from my work with the faculty of engineering and IT at University A (Bernice and Charlie). My prior acquaintance with them might have influenced them to participate, but I made no attempt to contact them beyond the emails sent to all potential participants. I did not discuss their participation with anyone else, nor did I refer to it if I had professional or personal exchanges with them as colleagues at University A.

3.3.3 Ethical considerations

In line with good ethical practice, I gained approval from the human ethics committee to recruit participants for this research (UTS HREC Approval Number: 2013000398), and followed the ethical guidelines in recruiting participants, ensuring that I had their informed consent and that I attempted to minimise any distress that might occur to the participants as a consequence of their involvement. As a researcher I take my ethical responsibilities seriously, and aimed to minimise any potential harm in the following ways:

1. Informed consent: Through transparent processes to gain participant consent the possibilities for harm were highlighted as well as strategies for minimising harm. Once the research participants had agreed to be involved in the study, they were given additional information about the study, and were asked to give their informed consent. Each interview participant was asked to read and sign

[1] The participant could be identified if his discipline were named, so for ethical reasons I have named his discipline 'integrated engineering'.

the consent form which also foregrounded their right to withdraw for any reason. No participant chose to withdraw. Details of the recruitment emails, consent forms and ethical storage of data are in Appendix A.

2. Safe environment: The interviews were held at a time and place that were convenient for the participants, and in environments that were typically seen as safe and non-threatening by faculty staff; all interviews were conducted in the participants' offices, with the exception of one who chose to be interviewed in a staff common room, making the interview difficult to transcribe because of the background noise.
3. Confidentiality: Reference to individual participants, in any written texts produced as part of the research, has been de-identified; this includes reference to faculties/institutions and so any distress caused by having personal perceptions made 'public' has been lessened.
4. Overall ethical processes: Ethical data storage has also minimised risk for participants by not making their words and views public.

While no harm was intended, invasion of privacy, embarrassment or distress could have resulted in unforeseen ways. No physically painful processes were involved. However, participants were discussing their own perceptions, which may have involved some level of personal disclosure. These perceptions may have involved emotions and it was possible (although unlikely in an academic context) that talking about their perceptions of writing, particularly of their own writing, may have embarrassed or distressed some participants. Confidentiality of their responses was assured as far as possible. It was also possible that participants may have believed that there was some risk to their academic reputation (e.g. if they provided perceptions that might be viewed as negative by their faculty or university). However, the interviewer (through 'informed consent' processes) reassured participants that individual comments will not be passed back to the faculty or institution, and that pseudonyms have been used when their actual words are used in publications.

3.3.4 Methods of data collection

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 collected. After an initial analysis of the documents, the research participants were invited to be interviewed to explore their perspectives of writing in the engineering curriculum, about how they 'see' writing in the engineering curriculum and in engineering practice; this interview was audio-recorded. Follow-up emails were sent to some participants to include an additional question that had not been asked in the original interviews. Participants at University A were asked if I could observe them while they were teaching. Three participants agreed and were observed. During the observations, notes were taken and transcribed for analysis, but no audio or visual recording was undertaken.

During and after the process of data collection and analysis, I kept a set of notes that recorded observations, questions, refinements of the research questions and commentary on what I was learning from my research. These notes were used as a reference point throughout the research. Table 3.2 below summarises the data collection methods. Each method is explained in more detail below.

Table 3.2: Summary of data collection methods

Data collection methods	Brief description of methods
Semi-structured interviews	An interview was conducted with each participant, with a duration of 45 minutes to 90 minutes. All interviews were audio-recorded and transcribed.
Participant documents	All participants were asked to provide subject outlines, additional learning guides and assessment documents (e.g. additional information about assignments, assessment criteria) and samples of students' written work (with the consent of the students). All participants provided subject outlines and assessment documents. Not all participants had samples of student work; four participants provided student assignments.
Publicly available documents	These included published journal and conference papers written by the participants. All but one participant (Charlie) had published writing.
Follow-up emails to participants	These were emails to the first four participants about an additional question that was included after their interviews were completed. All four replied to the email.
Participant observations	Four participants from University A were asked if I could observe their teaching. All agreed, but one participant (Eric) was no longer

	teaching the subject that was part of the case study/site of practice, so he was not observed.
Notes re progress of research	These included questions, observations and a running commentary about the data collection and analysis.

3.3.4.1 Interviewing

The main sources of data used in this research are interviews, document analysis and observations of teaching practices. Interviewing provides opportunities for interviewees to give detailed responses about their experiences, motivations and beliefs (Gill et al. 2008), and allows the researcher to glimpse the research participant's perspective (Patton 1990, p. 278). As the focus of this research project is on engineering educators' perspectives of writing practices in the engineering curriculum, it was crucial to explore in some depth the participants' ideas, understandings and experiences of these practices in the context of their site of practice.

The research participants were 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. All participants were asked the same set of questions about learning outcomes, the role of writing practices in the engineering curriculum, expectations about student writing and the participants' own writing practices. Questions about teaching and learning activities and assessment tasks varied; these questions were based on an initial analysis of subject outlines and related documents which were provided prior to the interviews taking place; participants were invited to check the accuracy of the document analysis. Additional questions were asked if a more detailed response appeared to be needed (see Appendix B for the list of questions asked of all participants). The interviews began by asking the participant to describe the main learning outcomes of the subject that they taught, and moved onto the role of writing in their subject, and approaches to assessing and developing students' writing practices, before asking the participants' about their own writing experiences and practices.

The interviews were audio-recorded with the consent of all participants, and lasted between 45 minutes and 90 minutes, depending on how long each participant wanted to talk. The interview recordings were transcribed by a professional transcribing service; I then checked the transcriptions using the audio recordings to ensure accuracy and to correct any errors made by the transcribers. After interviewing the fourth participant, an additional interview question was added about whether the participant would fail students on the basis of the quality of their writing; this question was emailed to the earlier participants, who all responded via email. Their responses were included in their interview transcripts with a note to indicate they were added post-interview.

3.3.4.2 Documents

The documents provided by the research participants were analysed to identify practices of writing, teaching, learning and assessment. The analysis consisted of examining documents to see where these practices were specifically mentioned, to examine the assessment descriptions, weightings, rubrics, marking criteria and other relevant information.Subject outlines were analysed for assessment tasks involving writing and any other writing tasks to see where writing was seen to be developmental and where it was 'invisible'. Learning guides and support documents to assist students in completing assignments were analysed to see where writing practices were seen as formative or summative assessment tasks, and for any examples of text types or exemplars. Published writing by the participants was analysed both as a way of inviting discussion by the participants about how they view their own writing in engineering and as a way of exploring the relationship between context and text. The collection of this kind of data is in line with that proposed by Ivanic when she developed her framework for analysis of data about writing pedagogy:

> …a framework which I have developed for the analysis of a variety of types of data concerned with the teaching of writing: …policy documents, teaching and learning materials, recordings of pedagogic practice, interviews and focus groups with teachers and learners... I propose that such data can be analysed for evidence of the underlying beliefs of those from whom it originated. (2004, p. 220)

As suggested by Ivanic (2004), the data collected for this study were expected to reveal some 'evidence of the underlying beliefs' (p. 220) of the research participants.

3.3.4.3 Observations

Three participants (Adam, Bernice and Charlie), all from University A, agreed to being observed while teaching; I attended their lectures or tutorials and took notes, trying to ensure that my presence in their classroom was unobtrusive and avoiding any interaction with students. This was not always possible; students in one lecture assumed that I was a fellow (ancient) student and would pass me lecture handouts, or would seek to include me in their group discussions. I explained that I was just sitting in. I transcribed the notes from the class observations and these became part of the data analysis. Due to time and resource constraints, it was not possible for me to observe the teaching of participants from other universities.

3.3.4.4 Notes on research

I kept a set of questions that occurred to me during the process of data collection and analysis; these notes served as a record of the shifts in perceptions and understandings that developed throughout the process of conducting this research, and as a prompt to explore different angles throughout the data collection and analysis.

3.3.5 Choosing to focus on engineering educators' perspectives

The focus on uncovering engineering educators' perspectives about writing meant that I decided not to include engineering students' perspectives, or those of practising engineers. Chapter 2 refers to a number of studies that investigated student writing in the engineering curriculum. Many of these studies combined the perspectives of engineering students, engineering educators and practising engineers about writing practices (e.g. Carter, Ferzli & Wiebe 2007; Fischer 2015; Hilgers, Hussey & Stitt-Bergh, 1999; Leydens 2008; Paretti 2008; Paretti & McNair 2012; Winsor 1990, 1996), but engineering educators' perspectives of writing practices remain under-researched.

3.4 Data analysis

The nine research participants became nine case studies in line with case study methodology; the subjects that they taught, including teaching and learning activities and assessment tasks and practices as demonstrated through documents and interviews, became their sites of practice as informed by practice theory (e.g. Kemmis

2014; Schatzki 2002). As previously mentioned, the boundaries of each case study comprised the research participant, the engineering subject they coordinated, teaching and learning activities in that subject, observations of teaching (where possible and permitted), any associated assessment tasks that the engineering students were expected to do, any writing that the students did as part of the subject (where provided by the participant), and published writing by the research participant. The research study, including data collection and analysis, was a recursive and iterative process. The case studies were snapshot rather than longitudinal (Starman 2013), as the research questions centred on engineering educators' perspectives of writing practices, rather than changes in perspectives or evolution of perspectives. The use of practice theory perspectives also emphasised the site-specific focus of the analysis. An iterative and recursive approach was adopted for the analysis, particularly with the interviews, as they were a rich form of data.

The preliminary research design was informed by activity theory, so the initial approach was to construct an activity system (Engeström 2001) for each research participant, using the engineering subject as the unit of analysis. The interviews were first analysed using a combination of responses to specific interview questions and Concordance (Watt 2011), a software program that identifies frequencies and patterns of words within a linguistic corpus. Using the expertise developed from my background in text analysis of English literature and from my work as an applied linguist, I analysed the interviews to identify key terms, key themes, and dominant practices. From this analysis emergent themes began to appear. These themes were then re-analysed along with the participants' documents to construct activity systems. Again, my expertise in text analysis provided me with the tools to analyse the language of the documents not only to identify themes, but to see what information was included and what was absent. The thematic analysis was used to 'zoom into' the activities within each system, to 'focus on the mundane activities at hand' (Nicolini 2012, p. 221). The activity systems showed the interactions among the elements of the system. Activity theory analysis was then employed to 'zoom out', to identify tensions and contradictions, including contradictions and tensions between the reported perspectives of the subject coordinators about writing practices and the activities in the site, following Behrend (2014) who has used action research and activity theory in a similar way.

At this point in the analysis it became clear that although activity theory was very valuable, another framework was needed to understand the causes behind the tensions and contradictions in the activity systems; as Nicolini argues, the use of the activity theory triangle ‘foregrounds the structural elements of the practice to the detriment of its processual dimension’ (2012, pp. 119-120). The adoption of PAT expanded the focus to provide space to see the arrangements or practice architectures that prefigured the practices within each site of practice. The data were re-analysed within a PAT framework, incorporating the tensions that had been identified from the activity theory analysis. The ‘project’ of a practice from a Schatzkian practice theory perspective relates strongly to the objective of an activity – both refer to ‘the intended outcomes of that process’ (Blackler & Regan 2009, p. 164). Moving from an activity theory framework to a PAT framework provided the opportunity to clarify what I saw to be the intended outcomes of participants’ sites of practice. Notes from observing three participants’ teaching practices were added to the picture, which then allowed prevailing practices and practice architectures to be revealed. This process highlighted arrangements that constrain and enable different practices in the participants’ sites.

When applying the PAT framework it was important to clarify what was meant by arrangements or architectures, and what was meant by elements of a practice – the ‘sayings, doings and relatings’. Schatzki’s explanation, referred to earlier: ‘Orders are arrangements of entities (e.g. people, artifacts, things), whereas practices are organized activities’ (2002, p. xi), was useful in this regard; especially when informed by Kemmis’s explanation of the composition of a practice (e.g. Kemmis 2012). The danger of over-categorising has been noted by other researchers using a PAT framework. Mahon warns that ‘… there is the potential, when using a practice architecture lens, for the categories, which are only analytical categories, to take over the analytical process’ (Mahon 2014, p. 257). A related issue, previously mentioned in Section 3.1.2, was to avoid disaggregating practice architectures when analysing sites of practice, although it can be tempting to consider cultural discursive arrangements, material-economic arrangements and social-political arrangements separately. In order to overcome these analytical challenges, an approach was adopted that considered prevailing or dominant practices which had been identified as common to several sites of practice. The arrangements that prefigured the prevailing practices in each site were then identified to see how they constrained and enabled particular practices.

It was important to keep in mind that constraints and enablements are themselves neutral terms: a practice that constrained one type of learning could enable another. For example, a practice of asking students to submit draft reports for formative feedback could constrain the belief that writing is an end product, and could enable the view that writing is a process to be practised. Assessment practices that measure the acquisition of propositional knowledge may enable learning approaches which focus on memorising and may constrain more integrated approaches.

Prevailing practices that constrained and enabled writing practices in the engineering curriculum emerged in several sites of practices through an iterative approach to data analysis. Other sites of practice were then analysed to see if these prevailing practices were in evidence, and if so what were the practice architectures that held these practices in place. If the prevailing practices were not in evidence, the sites were analysed to see why this was so. These findings became the building blocks of the thesis chapters which follow.

3.5 Conclusion

In order to investigate the perspectives of engineering educators about writing practices in the engineering curriculum I have used a case study approach, informed by practice theory perspectives. This has provided the opportunity to collect thick rich data using a range of data collection methods. Iterative data analysis, using the framework of PAT, has allowed answers to the research questions to emerge. These findings are discussed in the following chapters.

The next chapter, Chapter 4, uses the theory of ecologies of practices to see where practices in the participants' sites of practice either support or 'starve' writing practices, and considers the practice architectures that enable certain practices to thrive while constraining others.

Chapter 4
'Writing is important but'…: Ecologies of Practices for Writing Practices in the Engineering Curriculum

This is the first of the findings and discussion chapters and utilises the theory of practice architectures and ecologies of practices to argue that prevailing practices in the engineering curriculum do not support writing practices, resulting in writing practices that are unsupported (or suffocated, in the terminology of ecologies of practices) beyond a local site of practice. Chapter 2 discussed the research questions and introduced the theory of ecologies of practices as an extension of PAT. Chapter 3 outlined how PAT and the theory of ecologies of practices are used as analytical perspectives to interpret the data for this research. In this chapter (Chapter 4) the theory of ecologies of practices is employed to analyse the extent to which writing practices are starved or nourished in the sites of practice of the case studies. The chapter begins by discussing whether the Australian engineering curriculum has an ecology of practices to sustain writing practices. The chapter then outlines what is meant by unsupported writing practices in the Australian engineering curriculum, and presents an ecology of practices which could support writing practices in the context of this study. The following sections use this lens to consider the extent to which writing as a practice exists and is supported in the sites of practice. Six of the case studies have been assigned to one of two groups according to whether the practice architectures in their sites of practice do or do not support writing practices.

4.1 Ecologies of practices for writing practices in Australian engineering faculties?

As has been established in earlier chapters of this thesis, engineering employers, engineering faculties and engineering educators expect that engineering students will automatically graduate with high level written and oral communication skills, 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; Royal Australian Engineers 2007; Sheppard et al. 2009). A key reason for many engineering graduates lacking strong communication skills is posited to be the engineering curriculum's focus on technical knowledge, a teaching approach of knowledge transmission rather than knowledge co-construction, and the perspective of writing as a means of reporting results, not as negotiating meaning. The tension between what is emphasised in the engineering curriculum and what employers want is captured in the following 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 of the separation of writing practices from the learning of technical knowledge. Writing practices are often seen as competing with technical knowledge for scarce resources such as time in class, time needed for marking, and space in the subject for assessment tasks and learning outcomes.

In Chapter 2, Section 2.4.3, the Education Complex was presented as an illustration of an ecology of practices. It consists of five educational practices – educational research and evaluation; professional development/learning; educational leadership and administration; teachers' classroom educational practice (teaching); and students' academic and social practices (learning) – which are interconnected to form an ecology of practices. This ecology can support or suffocate practices: 'practices can sustain…or suffocate other practices, and different ecologies of practices may be hospitable to some practices and not to others' (Kemmis et al. 2014, p. 50). To continue the ecological metaphor, a niche is 'the conditions of possibility for a practice', where the necessary practice architectures are in place for a practice to exist or be sustained (Mahon et al. 2017, p. 23). It can be argued that the practice landscape of the Australian engineering curriculum does not for the most part have a niche for the ecology of practices that would sustain writing practices. It is difficult to locate ecologies of practices that might support writing practices throughout the engineering curriculum. As pointed out in Chapter 1, Section 1.2.2, writing, except for the notation of numbers and equations, is absent from most engineering subjects in first year

(Goldsmith, Willey & Boud 2012), and is even harder to locate in second year subjects. The prevailing practices in Australian engineering faculties for the most part do not nourish teaching and learning practices that encourage writing practices. They are not hospitable to writing practices; they do not provide intersubjective spaces – semantic space, physical space-time and social space – for writing to be spoken about as a knowledge practice, to be practised as part of engineering studies, and to be valued as a relevant and important aspect of engineering knowledge. To quote Yagelski about how writing is generally seen in literacy education: 'It is not even a practice, as we tend to think of writing as a practice…Rather, it is a procedure—and usually a tedious one at that' (2012, p. 189). In the engineering curriculum writing is often viewed as tedious – consider also Nagle's comments (1996, p. 6) about writing being seen as 'a quasi-clerical chore' by practising engineers, separate from the real work of engineering. Moreover, there is frequently little instruction about how to undertake the 'procedure' of writing. As a direct or indirect consequence of this view of writing, writing practices in some sites of practices are unsupported, as discussed in the following sections. Where writing practices do exist in sites of practice, for the most part they are not supported beyond that site. Furthermore, if there is a change in the local site of practice such as a change of subject coordinator or an increase in the size of the student cohort, even those existing writing practices might disappear.

Kemmis and colleagues claim that:

> …transforming education thus not only requires more than just changing teachers' pedagogical practices and the practice architectures that support their teaching, it also requires changing *the ecologies of practices* that exist in particular sites, including particular practices of student learning, particular practices of teaching, and particular practices of professional learning, leading, and researching. (Kemmis et al. 2014, p. 53; emphasis in the original)

Such requirements may explain in part why writing practices in the engineering curriculum keep disappearing from sites of practice, and why they are so hard to sustain. The conditions to enable writing practices to be sustained throughout an engineering degree program demand more than the goodwill of a single engineering educator to encourage their students to develop their writing practices in one site of practice. An ecology of practices is needed, comprising practices where writing is spoken of and thought of as a practice; where it is practised and given formative feedback; where it is weighted as part of the assessments; where it is seen to be developmental and as forming part of an engineer's professional identity. Writing has to be embodied, materially mediated, situated, relational and emergent (Rooney et al. 2015, p. 20) for it to be a practice that can be integrated into the teaching practices of engineering educators and developed as part of the learning practices of engineering students. This idea is explored in the later sections of this chapter. The next section discusses the concept of unsupported writing practices in the Australian engineering curriculum.

4.2 Unsupported writing practices

4.2.1 What is an unsupported practice of writing?

An unsupported practice of writing is where the practice architectures and elements of practice provide no intersubjective spaces for writing practices. Instead it is often the case that all the space is taken up with practices that support the teaching and learning of propositional knowledge. Shove, Pantzar and Watson (2012) claim that practices are in competition for time and space, and argue that 'practitioner-time [is]…a necessarily limited, inherently finite resource, the allocation of which reflects the relative dominance of some practices over others…' (p. 127). This competition is enacted in the sites of practice in this study and is evident in the sayings of the participants when they talk about how little time there is to cover all the topics in the subject and the cost of marking written assignments compared to marking quizzes.

It could be argued that in such circumstances, writing is not a practice but an activity; it does not fit the characteristics of a practice (Rooney et al. 2015). Unsupported writing practices can be identified by comparing the text types that students practise in class or for homework exercises with the text types they are required to produce for summative assessment tasks. Table 2.1 from Chapter 2 of this thesis is reproduced below for ease of reference.

Table 2.1 (reproduced from Chapter 2): Types of writing practices in the engineering curriculum and examples

Type	Example
1. Form-filling	Completing a template
2. Drawing & sketching	Freebody diagrams
3. Numerical notation	Noting measurements in lab sessions
4. Formulae & equations	Using formulae to solve problems (in labs or lectures)
5. Short Report writing < 3 pp.	lab reports, computer reports
6. Extended report writing > 3 pp.	Field reports, project reports (group or individual)
7. Reflective writing	Reflective journals, reflective reports
8. Thesis or capstone project	Honours thesis, capstone project (group or individual)

Engineering students perform notation in many of their learning practices – writing formulae or calculations, filling in tables, completing forms that require numerical information – which is writing as defined by Winsor (1992), and classified in Chapter 2, Table 2.1 as text types 1-4, but they do not practise writing as negotiated meaning. Assessment tasks such as a report or an extended answer in an exam call on a different knowledge, where students will need to be able to write beyond notation in order to justify a decision, evaluate results or recommend the optimum course of action. The practice of writing discursively, or writing as knowledge-making (text-types 5-8 in Table 2.1) is missing from the bundle of practices that is part of the pedagogy. A consequence of this is that the notational text that the students are writing is functional within the context of learning and practising propositional knowledge in labs and tutorials, but not beyond that context. The learning and practising of discursive writing, with its textual features, rhetorical force and logical functions can be said to be unsupported. The contrast between what students write and what their engineering educators write can be seen in Table 4.1, which summarises the writing practices of the participants in this study as reported by them.

Table 4.1: Types of writing practices reported by the participants in this study

Participant	Text types
Adam	One-pagers; a nine-book compendium of documents on design flood estimation; emails; reports; ministerials; technical papers; research articles; conference papers; presentations
Bernice	Project documents: (scoping, conceptual design, recommendations, conceptual report, sketches with notes, site instructions); evaluative reports for clients, tenders, presentation notes, lecture notes, research articles; conference papers
Charlie	reports for project management: – financial reporting – preparation of courses in software engineering – scope definition or high level business plans, systems definitions; professional writing courses [while employed by American Express]; writing the learning guides; writing instructions [to students]. Assignments for Grad Cert in HE (including reflective writing); emails to students
Damien	Research reports; reports for managers; newsletters when leading a project team; research articles; technical papers; conference papers; report writing guide for students
Eric	Research articles; conference papers; chapters in books; grant applications
Felicity	Thesis; thesis reports; conference papers; research articles; literature reviews; technical documents
Garth	Thesis; research articles; project reports; team project reports
Harry	Research articles; conference papers; theses; notes; assignments (for Grad Cert in HE); drawings; emails; telexes; writing in a log book
Ivan	Consulting reports; lab reports; journal articles; chapters in books; conference papers

The differences in students' and engineering educators' writing practices could be explained in part by the predominant teaching practices in the engineering curriculum (and in the wider university curriculum), where lecturers teach as they were taught, and are thus not necessarily aware of concepts such as scaffolding learning and modelling practices**.** Edwards comments that awareness of developments in pedagogy 'in higher education are not priorities for most academics' (2001, p. 165). This is a particular frailty of higher education in Australia, where knowledge of pedagogical theory and practice is not yet seen as a mandatory requirement for academic teaching staff. As is pointed out in a Grattan Institute report on the quality of university teaching in Australia: '[h]istorically, academics have had little or no preparation for teaching. They were simply expected to develop into their teaching roles through trial and error, with limited support' (Norton, Sonnemann & Cherastidtham 2013, p. 20).

The differences also illustrate the often-commented on lack of competence in written communication of new engineering graduates (as discussed in earlier chapters), and show how writing practices are frequently unsupported; this is explained in more detail in the following section.

4.2.2 Unsupported writing practices in the Australian engineering curriculum

That writing practices are frequently unsupported in the Australian engineering curriculum can be seen through examining subject outlines and assessment requirements. As discussed in Chapter 2, Section 2.2.1, writing excluding notation may not occur at all in many subjects (Goldsmith, Willey & Boud 2012). The majority of assessment tasks in engineering subjects are focused on producing artefacts based on calculations rather than on reasoned justifications (the 'project' of the assessment practice, in practice theory terms). This is also reflected in the weighting of assessment tasks; a final two- or three-hour examination will usually have a weighting of 60-70% (Goldsmith, Willey & Boud, 2012) but it is not uncommon that a report of several thousand words is given a weighting of 5-10% (Goldsmith & Willey 2016a). Moreover, when students are required to write in their engineering subjects it is difficult to find evidence of opportunities for them to practise writing in tutorials or laboratory sessions, in contrast to the intersubjective spaces provided for practising calculations and doing worked examples of problems. Unlike the development of students' propositional or technical knowledge, writing is mostly not practised formatively, yet it is assessed summatively in the reports that students are asked to produce. It is interesting to note in passing that the theme of competition for space and time in the engineering curriculum is picked up by Skinner and colleagues in their research on engineering students' use of online resources to support their writing (Skinner et al. 2012). While not all practices in the engineering curriculum constrain the development of writing practices, the practice landscape appears to render them invisible, ephemeral or unsustainable. The remainder of this chapter explores the notion of ecologies of practices that constrain or enable writing practices in the case studies.

4.3 Ecologies of practices in the case studies

About the practitioners:

Table 4.2 gives brief information about the participants' sites of practices (the subjects they teach), including whether the subject is an early or later stage subject, the size of the student cohort, how the subject is delivered (block mode or weekly sessions: none of the subjects is delivered in distance or online-only mode), and the engineering discipline of the participants. This information can be used to develop more of an understanding of the local conditions of the participants' sites of practice, and of the variations that exist within the engineering faculties where the participants teach.

Table 4.2: Sites of practice of the research participants

Name	University	Subject (site of practice)	Cohort size	Subject delivery Weekly/block mode	Engineering discipline
Adam	A	Later year subject	54	Block mode face-to-face	Civil engineering
Bernice	A	1st year subject	120 /250*	Weekly face-to-face	Civil engineering
Charlie	A	2nd year subject	200	Weekly face-to-face	Software engineering^
Damien	B	2nd year subject	80	Weekly face-to-face	Integrated engineering#
Eric	A	3rd year subject	60	Weekly face-to-face	Electrical engineering
Felicity	C	3rd year subject	110	Weekly face-to-face	Electrical engineering
Garth	C	3rd year subject	300	Weekly face-to-face	Civil engineering
Harry	D	1st year subject	56	Weekly face-to-face	Electrical engineering
Ivan	E	2nd year subject	300	Weekly face-to-face	Civil engineering

*Autumn/Spring
^Charlie teaches in software engineering but his subject is part of the engineering internship program in his faculty.

Adam's is the only subject that is not delivered in weekly lecture/tutorial/laboratory sessions. The cohort sizes for all subjects vary slightly from year to year; not all participants provided information as to whether their subject runs once a year or in both Spring and Autumn semesters. As explained in Chapter 3, there was no intention to recruit participants from specific engineering disciplines, so it is a coincidence that the majority of the participants were from either electrical or civil engineering.

This section presents the data analysis of the case studies which identifies practices which do or do not support writing practices in the sites of practice. Based on the data analysis of interviews, documents and observations, an ecology of practices that support writing practices in the engineering curriculum has been identified as follows and as summarised in Table 4.3 These practice architectures and elements of practice (the cultural-discursive arrangements and sayings, the material-economic arrangements and doings, and the social-political arrangements and relatings) interact and interrelate to create a niche where writing practices can flourish within and beyond the site of practice. Such an ecology of practices is discussed in more detail in Section 4.4, as exemplified in the sites of Bernice, Harry and Damien.

Table 4.3: Ecology of practices to support writing practices in the engineering curriculum

Cultural-discursive	Material-economic	Social-political
Writing is spoken of and thought of as a practice; written communication is a specific learning outcome of the subject	Writing practised in class or online; writing given formative or summative feedback; writing modelled and/or exemplars provided; writing given specific weighting in assessment tasks	Writing part of the subject assessment; writing practices part of the identity of the professional engineer; writing practices linked to other subjects in the curriculum

Table 4.4 maps the practices that support writing practices to the case studies. In this table the case studies have been listed from left to right, based on the extent to which the practices in their sites support writing practices and form an ecology of practices.

Table 4.4: Practices to support writing practices mapped to case studies

Practices	Felicity	Garth	Adam	Ivan	Charlie	Eric	Harry	Bernice	Damien
Writing spoken of and thought of as a practice	No	No	No	No	No	Yes	Yes	Yes	Yes
written communi–cation a subject learning outcome	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
writing practised in class or online	No	No	No	Yes	Yes	No	No	Yes	Yes
writing given formative or summative feedback	No	No	No	No	No	Yes	Yes	Yes	Yes
writing modelled and/or exemplars provided	No	No	No	No	No	Yes	Yes	Yes	Yes
writing given a specific weighting in assessment tasks	No	Yes	No	No	Yes	partial	Yes	Yes	Yes

Writing part of the subject assessment	No	No	partial	No	Yes	partial	Yes	Yes	Yes
writing practices as part of identity of professional engineer	No	No	No	No	No	Yes	Yes	Yes	Yes
writing practices linked to other subjects in the curriculum	No	No	No	Yes	partial	No	Yes	partial	Yes

Six of the case studies for this research can be loosely assigned to one of two groups, in terms of the extent to which writing is seen to be a practice and is supported by an ecology of practices. The other three case studies fall somewhere in between these two groupings, as can be seen in Table 4.3. The first group, comprising the sites of practice of Adam, Felicity and Garth, has been identified as *writing as a skill*; there are so few features of practice and elements of practice – of writing being practised or of it being spoken of, enacted, or valued as a developmental practice (sayings, doings, relatings) – that it is either invisible or almost non-existent. An ecology of practices to support writing practices cannot be located. The second group – the sites of practice of Bernice, Damien and Harry – is identified as *writing as a supported practice*, where writing practices can be seen to be supported within or beyond the local site to varying extents, dependent on the practice architectures which allow writing practices to survive and perhaps to flourish.

Table 4.5: Grouped case studies by support for writing practices

Case studies	Practice architectures in sites of practice
Group 1: Felicity, Garth, Adam	*Writing as a skill*: Minimal opportunity to write; no formative feedback; writing given minimal weighting in assessment tasks; no connections with other subjects or colleagues to develop writing practices
Group 2: Bernice, Damien, Harry	*Writing as a practice within & beyond the subject:* writing is regarded as a practice; formative feedback; connections with other subjects & colleagues to develop writing practices

The following sections present analysis and discussion of the first group of case studies: those of Felicity, Garth and Adam – where writing practices can be seen to be unsupported as explained at the beginning of this section. The reasons for not supporting writing practices can only be guessed at, and may relate to writing as 'not my job', as less important, as outside the participant's expertise, and/or as too time-consuming in relation to assessing.

4.3.1 Case study: Felicity

Felicity (University C) teaches a technical third year electrical engineering subject that has pre-requisite subjects which students must complete prior to enrolling in this subject; the cohort size is approximately 110. The subject is 'a core unit [subject] that develops fundamental electrical circuit concepts essential for an electrical engineer working in areas that include the energy resources sector, the process industries, electric power generators, energy utilization, as well the electricity supply industry' (Felicity subject outline 2014, p. 1). The assessment of the subject consists of: in class quizzes (10%); a problem-solving task (group assignment) 40%; laboratory/practical experiments (10%) and a final exam (40%).

In Felicity's subject, there are five learning outcomes in the subject outline; it is a later year technical subject which emphasises the acquisition of propositional (technical) knowledge, but learning outcomes 3 and 4 are worded as though they would require students to write discursively.

> 3. Identify fundamentals of power system economics, generation costs, tariffs, market rules and performance.
>
> 4. Explain principles of single and three phase transformers operation and performance (winding, testing, losses and efficiency) (Felicity subject outline 2014 p. 2).

In addition, the description of the final examination for this subject suggests that students would be expected to produce answers involving extended writing: 'The final exam [written] of two hours in length will be aimed at evaluating problem formulation, general knowledge and the relationships of fundamental knowledge to the systems studied' (Felicity subject outline 2014 p. 3). However, there is no mention in the subject outline, nor in the interview, nor in the assessment documents, of writing, and no examples of it being practised – neither in the practice architectures nor in the practices. Thus students will be expected to acquire learning outcomes that assume writing as negotiated meaning, and will be tested on this, at least implicitly, but without any opportunity to practise this kind of writing. The writing of numbers (equations, formulae and calculations) is present, but this is not seen as writing by Felicity and may not be seen as writing by students, as demonstrated by what she says:

> *…rather than writing a report or providing some document they need to attempt different examples, questions during tutorial sessions…So – not for this case, for this unit [subject] – they do not need to write lots of reports…* (Felicity interview)

The practice architectures – the cultural-discursive, material-economic and social political arrangements and the elements of the practice, the sayings, doings and relatings – support the learning of technical knowledge. This is enacted by language, activities and the value put on propositional knowledge. At the same time, the practice architectures and elements of practices within Felicity's site constrain the practice of writing. In this site of practice, writing of any kind except notation is seen as *not* what the students need to do; the idea that writing could be used to explain the problems, that students could be expected to practise explaining in words as well as in numbers, does not seem to be a possibility. In other words, the propositional knowledge of the discipline in Felicity's site does not allow writing to be thought of as part of learning electrical circuit concepts; the cultural-discursive arrangements are 'constraining what it is relevant to say' (Kemmis et al. 2014, p. 32) or to think about the practice of writing in electrical engineering. Felicity's sayings focus on the technical knowledge that the students are acquiring, even when she is specifically asked about their writing practices, as seen in the following extract from the interview. It is as if she cannot actually see the writing practices herself:

> *RG: So what kinds of writing do the students do in your subject? They respond to the questions – what else? With the project – you said there is a project based assignment?*
>
> *Felicity: Yes. For instance, for this particular unit – as a part of the machines subject, we will ask them to design a transformer, CT, current transformer. To design that one they will start from scratch. They need to provide the windings…for instance if they need to run some sort of simulation they need to add some figures from – or the snapshot from the results…* (Felicity interview)

It should be noted here that Felicity had the least teaching experience of all of the participants – she had been a subject coordinator for less than two years at the time of the interview. It may well be that as she develops her teaching practices, she might find ways to support her students' writing practices as they learn the technical knowledge of her subject. From her response, it is difficult to see where the students do any writing; the examples she gives are figures and screenshots of results, not words. The assignments are projects with reports but the emphasis is on accuracy of calculations and solutions, not on explanations or evaluations, as can be seen from the extract from the criterion referenced assessment document for the second assignment in the subject (see Figure 4.1 below). Felicity comments that students need to evaluate which is the optimum design:

> *We usually ask them – see you need to consider this as some sort of product that you are going to develop; that you are going to manufacture. You want to sell it. How do you provide information to make others convinced to buy such a product?'.* (Felicity interview)

Yet there are no criteria that ask students to provide this information, or that assess the evaluations that the students make. The report is more like completing a template than writing a report from scratch: 'There is a booklet that – they need to fill that booklet, answer all those questions' (Felicity interview). The report format seems to be in a loose bundle of papers and there is no mention of report structure: 'There is some sort of booklet, but in terms of report they need to provide some sort of thing like that. Yeah, loose bundle again' (Felicity interview). In fact, the assignment description sounds more like a collection of solutions to problems than a report that presents findings.

Criteria	High Distinction (7)	Distinction (6)	Credit (5)	Pass (4)	Fail (2/1)
Parameters Calculation					
Hand Solutions (5%) • inductive reactance per phase • current carrying capacity of the overhead line • capacitive reactance per phase	All calculated parameters and solution steps are correct.	All solution steps and two calculated parameters are correct.	All solution steps and only one of the calculated parameters are correct.	All solution steps and none of the calculated parameters are correct.	Solution steps and calculated parameters are incorrect.
MATLAB Code (5%) • MATLAB commands are used appropriately • Script is clear and easily used • Calculations are performed correctly using appropriate commands • Consistent results from MATLAB code and hand solutions	All attributes demonstrated at the highest professional engineering standard and best practice.	Excellent demonstration of at least three listed attributes and at least commendable demonstration of the other listed attribute.	Acceptable demonstration of all listed attributes.	Acceptable demonstration of at least three listed attributes and inadequate demonstration of the other listed attribute.	Inadequate demonstration of analysis and characterising responses.

Figure 4.1: Extract from CRA for Felicity's subject assignment 2

The practices of writing an explanation, justification or evaluation are missing; the 'reports' in this subject appear to be sets of calculations and completed tables of information (no exemplar student reports were provided to me), so students do not even practise structuring or formatting a report. Additional information for the students is provided by verbal explanations (sayings) that are not evidenced in the documentation: 'Also, we try to explain – prior to each session we try to explain what we are expecting from these questions. For instance do they need to answer – just give a brief answer' (Felicity, interview). So each semester the same explanations are given, or similar, or different, depending on who is doing the explaining, and who is hearing the explanations. These cultural-discursive, material-economic and social-political arrangements, whereby information about report writing and criteria for performing the tasks are undocumented and variably explained, suggest that writing is not seen as a practice. It also begs the question: why not have this information in the assignment outline? Descriptions of what to answer are provided in assessment documents, so it would not be burdensome to add a brief outline of report formatting and structure. Examples of concise descriptions of how to answer can be seen in the assessment documents of Bernice and Harry (see Section 4.4).

Felicity's sayings, doings and relatings indicate that in her site of practice, the development of writing practices is not necessary; there are no intersubjective spaces for writing practices to be talked about, enacted or seen as relevant. The practice architectures and elements of practice interact to ensure that the students develop the propositional knowledge which fits into the building blocks of electrical engineering technical knowledge. When asked about students' prior knowledge or experience of writing practices:

> *RG: …Do you know whether students have done these types of writing practices before? Do you know if they've done group projects before or group assignments before?*

Felicity's answer initially suggested that students would have had prior experience of writing group projects but then acknowledged that pre-requisite subjects would have taught them about circuit design, giving them the propositional knowledge needed in order to undertake her subject.

> *Felicity: We usually design our unit outline based on the prerequisites for this particular unit. For instance we need to know for each of the students who are going to sit for this one – as you can see here [pointing to the subject outline] – prerequisites – they have to pass this unit and this unit. Basically, in these two units they will learn more about the project based assignment. They will learn – actually they learn more about the circuit design, whatever they need to know for this unit.* (Felicity interview)

Chapter 2, Section 2.3 discussed the separation of knowledge from language that occurs in technical disciplines such as science and engineering; in Felicity's site of practice we can see the separation being enacted. This demonstrates how the practice architectures of her site of practice – the cultural-discursive, material-economic and social-political arrangements – interact to 'suffocate' writing practices through a lack of support. 'Suffocate' here is used (as it is by Kemmis and colleagues) in the ecological sense of practices not being allowed to 'flourish' – they are instead figuratively 'starved of oxygen' or 'suffocated'.Writing practices are not present in the subject outline, they are not enacted in the tutorials, they are not given weighting in the assessment tasks; they are not connected to previous or following subjects. Although Felicity says that knowledge of writing is important for presenting one's ideas: '...how to propose your idea in a better way. So it is quite important' (Felicity interview), there are few if any opportunities for students to see or to practise their knowledge of writing in her subject. As a consequence, the practice architectures of her teaching and learning practices will shape the academic practices of her students so that they will not expect writing practices to be part of the knowledge they need.

4.3.2 Case study: Garth

Garth teaches a third year civil engineering subject at University C; he has worked there for several years. The cohort size is approximately 300. Garth's subject outline states: 'assumed knowledge: previous subjects in engineering' (Garth subject outline 2014, p. 1), but does not specify pre-requisite subjects. The students in his subject have done two years of civil engineering, and Garth's subject introduces them to the key concepts involved in transport engineering. The assessment of the subject comprises: one problem-solving task – team submission (20%); one design task – team submission (20%); and a final exam (60%).

Garth's subject outline has six learning outcomes, including: '5. Apply a professional dialogue with specialists and non-specialists by way of written documents and drawings' (Garth subject outline 2014, p. 1)… 'You will undertake two problem based learning projects, in groups of four, emphasizing your team working ability and ability to communicate professionally' (Garth subject outline 2014, p. 3).

However, other arrangements do not support this; the sayings, doings and relatings contradict what is in the subject outline, so that his practices shape the practice architectures to render writing practices much less supported than they were intended to be by the previous subject coordinator. Garth says in the interview that there are no writing requirements in the assignments, only problem-solving questions that require mathematical equations. The subject outline was written by the previous coordinator to include group projects, and Garth took over the subject a few weeks before the start of semester – too late to make changes to the wording of the learning outcome or of the assignment (university regulations stipulate that subject outlines cannot be changed after a certain date, usually well before the commencement of semester). Garth replaced the group project with assignments that require students to solve mathematical problems. I tried to ask why the changes came about, but he didn't quite answer the question, and I was reluctant to pursue it because of his obvious discomfort about confessing that the subject outline did not reflect the actual tasks. The interview extract below shows the questions and responses:

> *Garth: I have to tell you the truth, honestly that unit outline was written by the previous coordinator…The two assignments, the students don't have to write anything in professional style. It is actually just problem solving questions. So they don't really have to describe anything, all right, they just solve some mathematical questions in transport and that's it. That really doesn't count, not really relevant but we still have it.*

RG: Do they do any other sort of project or report writing…

Garth: For this particular unit there is no project.

RG: Okay. Was there a project before? I'm just curious about how that learning outcome came to be.

Garth: The assignment. So for this unit there are two assignments.

RG: Two assignments, yeah. Okay.

Garth: One final exam. The assignment is just solely just math, equation and numbers, that's all.

RG: So no reports or…

Garth: No reports. (Garth interview)

The replacement of the group project with assignments that focus on maths and equations was possibly done in order to cover all the topics that were seen to be important:

> *So we have too many things that we want to teach and we only have 13 weeks. So we actually use tutorial times, most of the tutorial times, to teach something, do a practice. So I thought that is the best way to utilise the time but by doing that there's no practice actually for a student to improve their writing skill.* (Garth, interview)

Garth says to the interviewer that writing is important, but the doings and relatings of his practice show that it is more important to cover as many topics as possible, and to practise doing technical problems in tutorials. The weighting of assessment tasks is 20% for each of two assignments and 60% for the final exam. In each assignment the weighting for written communication, 'demonstrate effective written communication to an audience of discipline specialists', is weighted at 5% of the total marks, but the marking criteria refer to correctness: correct formatting, correct spelling and neat drawings. This directs students to focus on propositional (technical) knowledge.

Garth comments that a few years ago he would have expected students to be able to write descriptions, but now he knows the students so he no longer has that expectation. The social-political arrangements and relatings – Garth's low expectations of students' writing capabilities – interact with the other arrangements to 'starve' or neglect writing practices. Students look to the subject coordinator and to the subject documents to provide guidance on what they are expected to do and learn in the subject, and at what level. If the practice architectures of the site of practice do not support expectations of a certain level of writing quality – if the level of writing is not included in the subject outline or assessment descriptors, not practised or modelled in class, and not given meaningful weighting in assessment marks – it is at the very least unsupported, and arguably missing as a practice. Writing as a practice for students (and for staff) appears not to be taken seriously, and is not seen as integral to the development of engineering knowledge until the crunch time of fourth year (this is discussed in some detail in Chapter 6 on the invisibility of writing practices). Garth acknowledges the lack of emphasis on writing practices in the curriculum of his faculty:

> *Writing practice was not sufficiently highlighted in the current curriculum. We believe it's quite important but there are so many other important things that we want to include and teach.* (Garth, interview)

Garth's comment here epitomises the cultural discursive arrangements around writing practices in the engineering curriculum, and the view espoused by many engineering educators: writing practices are described as important until they compete for scarce resources and for status – the material-economic arrangements and the social-political arrangements in the engineering curriculum of space and relevance within the curriculum, of time on task, of teaching time, of the time taken to mark assessment tasks, and then they become less important. Because of these pressures, it becomes unthinkable and undoable to have writing practices take up space in the teaching activities of his subject 'because there are so many other important things that we want to include and teach'. This illustrates how the cultural-discursive arrangements, material-economic arrangements and social-political arrangements interact to 'starve' or 'suffocate' the practice of writing in the engineering curriculum. There is too little time in the class or the semester, or it is not someone's job to teach writing, or writing is important but not quite as important as the technical or propositional knowledge taught by the subject coordinator.

The final summative exam is expected to measure learning outcome 5, but there is no provision of practice or of modelling of the 'professional dialogue'. As in Felicity's site of practice, students are required to write descriptions and explanations in the final exam (worth 60% of final marks for the subject) without practising this type of writing during the semester.

> *RG: So what opportunities are there for students to practise their writing in your subject?*
>
> *Garth: Practise?*
>
> *RG: Yeah.*
>
> *Garth: Well, the report[2]. That's practice isn't it?*
>
> *RG: Yeah. So that's in [this unit]?*
>
> *Garth: Yeah. No, [this unit] is just a – well it's a math and equation.*
>
> *RG: But then in the exam you're asking them to do that kind of descriptive writing so I'm just wondering through the semester do they get opportunities to practise the kind of writing that they're being asked to produce in the exam?*
>
> *Garth: Unfortunately no. That's a good point.* (Garth interview)

Garth's comment suggests that he had not been aware of this omission previously. At the same time, he does not suggest that it would be a good idea to put in such practice, or that in future he might consider doing so. What would it take for him to make changes? He was embarrassed about being caught out removing the assignments that involved teamwork and writing, but he did not appear to be ashamed – for him, the technical problem-solving, the covering of all of the topics, was much more important than giving students the opportunity to solve problems in groups and

[2] In the interview Garth commented on a 4^{th} year subject he taught where students were required to write reports.

present their results in a project report. Was it just the amount of work that the projects would have involved? Time taken away from ‘the knowledge’? Or was it discomfort about having to provide formative feedback on the projects, as stated in the subject outline he didn’t have time to change? The subject outline says:

> You will undertake two problem based learning projects, in groups of four, emphasizing your team working ability and ability to communicate professionally… Both the formative and a proportion of the summative assessment for this unit are centred upon the completion of two engineering projects, which will be portrayed by way of two team submissions... You will receive feedback through group dialogue with teaching staff, written comments upon, and grading of your submission documentation, both of which will enable you to understand how your team is progressing and how your work may be improved. (Garth subject outline 2014, p. 3)

What Garth talks about and what the students apparently have to do bears very little resemblance to what was written in the subject outline by the previous coordinator, who sounds as though he/she has a stronger understanding of teaching practices that encourage experiential learning.

Garth’s sayings and doings in his site of practice, where there are no intersubjective spaces for writing practices to take place, indicate a lack of support for writing practices, as well as a lack of awareness that there is a lack of support. The prevailing impression is that of a subject coordinator whose teaching practices are shaped by the practice architectures of his school and of his previous experiences. These practices enable the acquisition of technical knowledge divorced from writing, and simultaneously constrain the development of writing as part of what and how his students could learn. There is a sense from his interview comments that Garth seems to lack agency, or to be unwilling to exercise it. He recognises that there are gaps in the system, commenting on this several times throughout the interview, but does not take steps to address these gaps, even when it is within his control to do so. In fact, he replaced assignments that developed writing practices with assignments that focused on ‘problem solving questions’. It may be that the practice architectures of his faculty seem so immovable to him that it would be flying in the face of nature to support writing practices. On the other hand, his is not the only subject outline that claims to develop communication skills without including teaching, learning, or assessment activities that provide opportunities for writing or speaking (Goldsmith & Willey 2016a). The separation of writing from content can result in students, who become graduates, focusing on reproducing information without considering who is to read it, or how it is to be understood and interpreted.

One interesting point is the contrast in perspectives about institutional support for writing practices within the faculty between Garth and Felicity (both from University C); Garth believes that members of his faculty see that there are problems with the writing practices, that the practices are not highlighted in the current curriculum, and that there needs to be improvement in the development of writing practices within the faculty. On the other hand, Felicity is very positive that writing practices are developed within the curriculum, and that her views are shared by the rest of the faculty ('yeah, definitely. We usually have regular meetings. We discuss all those issues in that meeting. How to improve'). This might be the difference between their practice landscapes – Garth is in the school of civil engineering, whereas Felicity is in electrical engineering – and may indicate differences in the social-political practice architectures of those two schools. Garth says that students have no other opportunities to study transport engineering except for this subject, unless they choose to specialise in it. On the other hand, Felicity expresses a sense of collegiality with her school and sees her subject as part of a sequence that students follow in electrical engineering. It might also be due to differences in perspectives – Garth refers to the faculty not having a serious discussion about writing practices: 'we have discussed a lot of things but writing, engineering writing, we've not really seriously discussed', whereas Felicity is commenting on the practice architectures of her school and of her own site of practice, which is a narrower perspective.

4.3.3 Case Study: Adam

Adam (University A) teaches a later year civil engineering capstone subject for undergraduate students which is also offered as a postgraduate subject. The cohort size is approximately 55 students. The subject outline does not specify assumed knowledge or pre-requisite subjects. 'This aim [sic] of this subject is to provide students with an understanding of flood estimation techniques from both theoretical and practical perspectives' (Adam subject outline p. 1). It is delivered in block mode: students attend three intensive two-day sessions over the semester: 'Each teaching period consists of 11.5 hours of mixed lecture and tutorial sessions' (Adam's subject outline 2014, p. 4) rather than attending weekly classes. The assessment of the subject comprises three assignments, each worth 20% and a final exam worth 40%.

Adam's subject has 12 learning outcomes which are mapped to the faculty graduate attributes: the seventh is '*Report writing*: Students learn to structure their reports according to expectations in engineering practice' (Adam subject outline 2014, p. 3; emphasis in the original).

> *RG: I notice that one of the learning outcomes is report writing. How do students learn that?*
>
> *Adam: All of the assignments are given to me in the form of a report so it's essentially, you're a consultant, give me the answer in the form of a report.* (Adam, interview)

Adam's response indicates a gap in his understanding about learning; students may not actually learn unless there is some direct instruction. In reply to the question 'what do you see to be the purposes of writing in your subject?' Adam makes the comment that 'At a deeper level it's an opportunity for students to learn how to write engineering reports'. However, Adam does not make explicit the opportunities for the students, nor the 'expectations in engineering practice', nor the assignment requirements. In the description of assessment tasks in the subject outline and in the documents that outline the assessment tasks, the word 'report' is not used for the first or second assignment; it occurs only in the instructions for the third assignment: 'Using results from assignment 2: *determine* design X...Any assumptions needed to develop the design X need to be *discussed* in the assignment *report*' (Adam Assignment 3, 2014, p. 1, my emphasis). The cultural-discursive arrangements and the sayings are in tension, which could well be a challenge for the students, especially considering that the subject is delivered in block mode, where opportunities to check assignment details and requirements would be limited. The students learn to write reports by writing (summatively assessed) reports. While they may be learning by doing, what they are doing is shrouded in assumptions which have not been made clear. There are tensions between what is in the subject outline and Adam's earlier comment when he says:

> *I tell them what I want in terms of that [report writing] but I don't really give them an example of one. What I would suggest is it's really a hurdle that – they've got to get over the hurdle without a lot of actual marks being attributed to that component.* (Adam, interview)

Adam does not explain why the hurdle is placed there, nor why there is little assistance provided for the students; nor, for that matter, does he explain why it is a hurdle with not many marks attached to it. Students are not provided with a model or an exemplar of what is required in the reports, nor are they given documentation about the structure or length of the report. This information may be given verbally in the lecture/tutorial sessions, as in Felicity's site of practice, and raises the same question about why it is not included in the subject documents. Adam's interview response, and his approach to assessing students' writing without practice or models, is an example of the silent narrative of writing in the engineering curriculum – that engineering writing is somehow to be acquired invisibly and without support, or that specifying what is required should not be necessary for students. It could also be that Adam is unaware of the level of writing that he is expecting from his students. In a study that involved collaborating with tutors and postgraduate engineering students on problem-based learning projects, Fischer (2015) reported that academic staff struggle to articulate their expectations of what students should produce in a written assignment, at least partly because they are not clear about 'the nature of the knowledge expected' (p. 83), and partly because both staff and students are not prepared for the complexity of the literacy practices required to generate both the writing and the knowledge created.

While Adam provides opportunities for his students to write (reports) in his subjects, there is no provision for practising report writing without being assessed. The sayings (what Adam tells the students), doings (requiring students to write reports) and relatings (the value and assessment of the report writing) interact to constrain the development of writing as a practice, and to enable the development of writing as producing an artefact. It is interesting that Adam says, and probably thinks, he is providing practice in report writing. He is certainly giving his students the opportunity to write reports, but practising strongly implies learning to do something, and having the opportunity to fail, without penalty. As noted, Adam acknowledges that there are few chances for the students to practise writing except when writing the assignments:

> *Very little, other than the assignments. They may choose to – you know, in answering those assignments they may choose to have a few drafts but there's no real time where they've got an hour spare to sit down and do something. It's one of the failings.* (Adam, interview)

Adam makes the comment that 'It's one of the failings', but it is not clear what the failing refers to: whether it is a failing of the block mode in which the subject is delivered, or of the subject coordinator not to provide the opportunity for students to write a draft or a failing of the students that they do not take the time to write a draft. As with the two other case studies in this group, there is little to no formative feedback given on students' written work, despite, in Adam's site of practice, the significant weighting given to the reports (60% of the total marks).

The subject description in the subject outline focuses on what will be learned in that subject; the only mention of other subjects is the following: 'Students will apply the theoretical knowledge developed in undergraduate or earlier subjects' (Adam subject outline 2014, p. 2). Adam answers the question: 'what assumptions do you make about prior experience or knowledge that they [students] might have in terms of report writing?' with: 'I assume they can write in English which is in many cases a bad assumption' (Adam, interview). While making allowances for a facetious reply, it is still clear that Adam does not have very high expectations of students' writing practices coming into his subject. Yet his recognition does not translate into providing practice in writing, nor in modelling writing practices himself, as was revealed in an observation of his teaching. I observed a revision session before the final exam where Adam adopted mainly a lecturing style and took a knowledge transmission approach to his teaching (Kember & Kwan 2000; Samuelowicz & Bain 2001), despite being in a tutorial room with clusters of desks and only six students in attendance. He talked at length and had PowerPoint slides with dense information. Every few minutes Adam would ask questions of the group of students; the questions were seeking to test students' propositional (or technical) knowledge. The students were visibly uncomfortable with this and either didn't venture an answer or whispered it. Most of the answers were apparently incorrect. Students were not asked to discuss the information in pairs or small groups, although they were sitting at tables where discussion and collaboration would have been quite easy and certainly less intimidating. In response to an interview question: 'what opportunities are there for students to practise their writing in your subjects?' Adam replies: 'Very little, other than the assignments', but from the observation of the session there were several opportunities to build incidental writing practice into the session; for example, asking the students to write down their response to a question and comparing answers with a fellow student before giving their answer to the whole group. A strategy such as this, known as 'think, pair, share', allows students to collaborate with fellow students, consolidate their learning, and practise the use of the language of engineering, all without taking up much time or involving marking. Adam is not alone in not adopting such a technique; many engineering educators do not use opportunities in their lectures and tutorials for students to practise such incidental kinds of writing. It is not known whether it is because they do not see it as a useful way of learning, or whether they would feel obliged to mark the students' writing, which would put an unbearable burden on their teaching. The obligation to mark written work stems from the cultural-discursive arrangement, the belief, that anything that students write needs to be given a mark or students will not do the work. This suggests a tension in Adam's beliefs and practices about developing the writing practices of his students. It is not clear whether he thinks it is not his job, or whether it is too hard a job, or whether the students should have already acquired these practices, but there are opportunities to develop student writing within his site of practice that he does not utilise. The ecology of practices in

Adam's site of practice, and perhaps throughout the practice landscape of his school of engineering, does not support writing practices.

4.3.4 Summary of analysis of Group 1 practices

From these three case studies we can see how the practice architectures and elements of practice in these three sites of practice interact to starve writing practices. Each site has specific and particular practice architectures, but the outcome is strikingly similar, showing how interconnected practices are.

If individual subject coordinators focus on what is taught only in their subjects, they may well lose sight of what and how students are learning throughout their degree programs. This would also militate against subject coordinators seeing that students' writing practices are developmental; if a subject coordinator is not aware of the type and level of writing practices that students have attained prior to enrolling in that subject, it is very possible that students may be asked to write at the same or a lower level, rather than building on their skills and knowledge. The separation of writing from content can result in engineering graduates focusing on reproducing the information without considering who is to read it, or how it is to be understood and interpreted. It is not enough to say that writing practices, or communication skills, are a fundamental part of engineering. These sayings need to be supported by the other elements of practice – the doings and relatings, and by the practice architectures of the practice; otherwise the sayings have no significance for the students. Most importantly, the practice architectures of one site need to interrelate with those of other sites to build a framework that supports writing practices within and beyond individual sites (engineering subjects) in order for engineering educators and students to see that writing is developmental and that it is a practice.

4.4 Supported writing practices in the sites of practice

In the following case studies there are practices which support the development of students' writing practices within their sites of practice, as can be seen from Table 4.1. The participants talk about the importance of writing practices as part of being a professional engineer, provide opportunities for students to practise writing, and provide feedback that supports learning, whether it is formative or summative. To varying extents, they also link the practices in their sites of practice with those of colleagues in their school, faculty and/or their university.

4.4.1 Case study: Harry

Harry teaches a first year second semester electrical engineering subject for students in the school of electrical engineering at University D, where he has worked for quite a few years. The cohort size is approximately 50-60 students. 'In this [subject] you will be introduced to several circuit analysis techniques, and be shown how these can be applied to the analysis of DC and AC circuits.' (Harry subject outline 2014 p. 1). The assessment tasks for this subject are: weekly pre-lab preparation (graded satisfactory/unsatisfactory); two lab reports (graded satisfactory/unsatisfactory); one lab report 20%; 2 class tests 10% each; final exam 60% (Harry subject outline 2014 p. 2).

Harry's subject has eight learning outcomes, including 'LO 8: Document and analyse measurements, interpret and explain results and observations, and summarise findings in a coherent and literate manner' (Harry subject outline 2014 p. 1). The subject outline includes a matrix that maps the assessment tasks to the learning outcomes so students can see the relationship between learning outcomes and assessment, as shown in Figure 4.2. It is a clear illustration of this relationship, and would make a fine exemplar for all subject outlines.

Outcomes-Assessment Matrix

The following table maps the assessment items to the Learning Outcomes listed earlier.

Assessment item	LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8
Lab activities	X	X	X	X		X	X	X
Pre and Post Lab Reports	X	X	X	X		X		X
Final Lab Report	X	X	X	X	X	X		X
Class Test	X	X			X			
Exam	X	X	X	X	X			

Figure 4.2: Outcomes-assessment matrix (Harry's subject outline 2014 p. 3)

The practices and practice architectures in Harry's site interact to support writing practices in the semantic space – the cultural-discursive arrangements and sayings – through the subject outline and assessment documents which refer to writing practices as part of the expected outcomes of the subject, and which contain clear and concise (one page) criteria about the structure, organisation and content of the lab report. The criteria distinguish between the quality of the analysis and presentation of the report, in contrast to the criteria used in Garth's site of practice. Harry says that writing lab reports, and practising to write lab reports, helps students to learn:

> *RG: so the students have to write lab reports in your course, why is that?*
>
> *Harry: Because that's when they actually start learning things.* (Harry interview)

Students are also encouraged (in the subject outline and in the assignment handouts) to reflect on their learning, and Harry comments on the need for students to think about what they have learned. The material-economic arrangements and doings support writing practices by requiring students to keep a laboratory notebook as part of preparing for laboratory exercises and tutorials (and assessed as satisfactory/unsatisfactory), in addition to the two lab reports which are graded pass/fail and which are opportunities to practise writing before being summatively assessed on the third report. The first two lab reports are given formative feedback which students are expected to incorporate into their third report. The social-political arrangements and relatings support writing practices by linking them to the learning of the propositional knowledge of Harry's subject and by making them a specific learning outcome of the subject.

His sayings, doings and relatings interact with the practice architectures to convey to the students the importance of making links between theoretical concepts and lab activities, and that writing practices are one way of both making those connections and demonstrating that knowledge to others. This is included in the assessment criteria for the lab reports which are given to the students prior to completion of the report: 'Include theory on the subject as it relates to this Lab exercise, including the theory required to predict or understand the results. Emphasise what has to be known before commencing the Lab exercise' (extract from Harry's subject Lab report assessment criteria).

The practice of giving formative feedback on the lab reports is built into the subject and is made clear to the students in the subject outline and in assignment instructions. Students are expected to use the feedback that they receive on the first two lab reports to improve their work on the assessed report. In one sense the feedback is both summative and formative, as there are penalties for failing the first two reports, but that may also operate as an incentive for students to complete all reports, and not just the final one: 'Final Lab Report (20%): due 1700 Friday 24th October (but with the Report mark de-rated by 4% for each unsatisfactory Pre-Lab exercise preparation, and de-rated by 30% for each fail grade for Lab 1 and Lab 2 reports)' (Harry subject outline 2014 p. 2).

Harry says the opportunities for students to receive feedback are very important, as can be seen by his comments below, and by the frequency of his use of the word 'feedback' in the interview (nine times):

> *The idea is to give the specific feedback on things that they haven't done well, and say why they haven't done well. This of course takes time which makes the whole assessing thing an expensive thing. But that's really where the value is in the teaching.* (Harry interview)

Harry is aware of the material-economic arrangements that can constrain or enable giving feedback on students' written work; as he points out, this 'makes the whole assessing thing an expensive thing', but he seems to see it as a cost-benefit analysis: 'that's really where the value is in the teaching'. This contrasts with Garth's comment that the teaching resources need to focus on students' acquisition of technical knowledge through practising problems in tutorials. It should be noted that the cohort size for Harry's subject is around one-fifth of the cohort size of Garth's subject, highlighting the different conditions of these two sites of practice. The competition for resources in terms of time and money on marking students' written work for several of the participants is discussed further in Chapter 7.

There is also a strong connection between the writing practices in Harry's subject and consecutive subjects in the electronics stream of the school of electrical engineering.

The following interview extract shows Harry talking about how he and his colleagues ask students to write reports in the DEC (design of electronic circuits) subjects that follow on from his subject:

> *But I do know in the DEC 2 and the DEC 3 [subjects], it's a lot like what we do in DEC 1. In fact we deliberately do that because we want to give them lots of – we think this is a good way of engaging them with the learning process. In the DEC stream of [subjects] they're doing similar things – they're learning theory, they're going doing lab work where they build stuff and they measure stuff and they compare that to theory and simulation. How do you evaluate that? Well you write a report that talks about it.* (Harry interview)

He sees his disciplinary team as a fairly cohesive unit, where all the members are aware of what the others teach, and all appear to have similar goals in terms of teaching and learning. Some of those shared goals are around developing students' writing practices as engineers. His comments show that not only is he aware of the writing practices of subsequent subjects, but that he and his colleagues in his discipline have chosen to build in these practices, and have discussed this:

> *RG: …do you and the other DEC [subject] coordinators actually work this out together, discuss this and say...*
>
> *Harry: Yes. [Laughs] I don't know, maybe it's a bit unusual.* (Harry interview)

He also recognises (perhaps from my facial expression in the interview) that it was not a usual practice amongst subject coordinators; in the current study this occurs only in Harry's and Damien's case studies. As in Bernice's practices, Harry says that writing practices are part of the development of a professional engineer, as can be seen in the following interview extract:

> *Harry: If we can develop these fundamental skills in being able to understand technical concepts and join the links between them and being able to critically evaluate some measurements and compare it to some underlying theory, if they can*

do that, then that's definitely preparation for their life as an engineer. (Harry interview)

The recognition of writing practices as part of the process of becoming an engineer is a thread in common with the other two sites of practice in this group, and is discussed in more detail in Section 4.5. Harry relates it to his own practices as a professional engineer, and to 'engaging with the learning process'; in this context he also refers a couple of times to having completed a graduate certificate in higher education after he was appointed as a lecturer to University D: 'I…enrolled in the Cert so I could actually understand a bit more about the whole learning process' (Harry interview). Mahon & Galloway (2017) when discussing what enables and constrains pedagogical practices of participants in their study on enacting critical pedagogical praxis comment on 'factors related to practitioner capacities (e.g., dispositions and knowledges)' (p. 187). Harry's disposition – in this instance, to choose to learn more about 'the whole learning process' – can be compared with Bernice's strong interest in teaching and learning, reflecting or indicating her disposition to learn about pedagogy. Their dispositions or 'practitioner capacities' are in contrast to the case studies in the first group, where specific reference to pedagogy or pedagogical understanding is absent.

4.4.2 Case study: Bernice

Bernice is a lecturer in civil engineering at University A, and has worked there for some years. She has a strong interest in teaching and learning and has been recognised in the wider university community for her expertise in this area, as well as in the Australasian and international engineering education community. She teaches a first year engineering subject for civil and environmental engineering students. The cohort size is approximately 125 in Autumn semester and about 250-300 in Spring semester. 'The subject aims to assist students to acquire a fundamental understanding of static equilibrium concepts commonly used in analysis and design of engineered structures' (Bernice subject outline 2014, p. 1). The assessment tasks for this subject are: four assignments (two reports) 40%; four in-class topic quizzes (mandatory no marks); a final exam 60% (Bernice subject outline 2014, pp. 3-6).

Bernice’s subject has five subject learning outcomes, none of which mentions communication, but there are also five course intended learning outcomes (CILOs) which map to the faculty graduate attributes, of which communication is the fifth: ‘Communicate effectively in ways appropriate to the discipline, audience and purpose’ (Bernice subject outline 2014, p. 2). The practice architectures of Bernice’s subject prefigure the development of students’ writing practices through and with the learning of the propositional knowledge in the following ways. The CILO in the subject outline, the clear and concise instructions given in documents of assessment tasks, linking assessment tasks to the learning outcomes and the equal weighting given to all parts of the assignment (Figure 4.3) all interact to make writing practices visible. Both the presence of the criteria in the subject outline and the equal weighting for all aspects of the reports enable students to see report writing as part of the subject.

Criteria	Weight (%)	SLOs	CILOs
Reports are formatted as such, with appropriate referencing, discussion sections that include discussion of the relationships between the variables and errors involved in measurement and analysis of these, and recommendations	25	1, 3, 5	C.1, C.2, E.1
free body diagrams are drawn clearly with all forces correctly calculated and labelled	25	2	B.1, C.2, E.1
Internal action diagrams are drawn clearly with relevant values correctly calculated and labelled	25	4	E.1
Problem solutions are clearly and accurately set out	25	1, 2, 3, 4, 5	B.1, C.1, E.1

SLOs: subject learning objectives
CILOs: course intended learning outcomes

Figure 4.3: Criteria for assignments (Bernice’s subject outline p. 4)

Bernice’s sayings, doings and relatings enable the development of student’s writing practices as part of the learning of propositional knowledge through collaborative activities in tutorials and interactive lectures. She comments in the interview that, ‘Part of the reason that I encourage collaborative problem solving is to get them [students] in the habit of using the language of the subject, the terminology and the way they talk about the concepts’ (Bernice interview). This is enacted in the tutorials, as can be seen from the observation of one of her classes:

…The atmosphere in the lecture is relaxed but task-oriented. The students know what to do, and seem to be clear about Bernice's and their own expectations of the purpose of the class. A problem is shown on a lecture slide and students are asked to solve it in groups. Bernice tells them they can solve it for acceleration or position first, and that someone will be asked to solve it out the front… Bernice reminds the students to 'use the brains trust around them'. (Notes from observation of Bernice's class 15.5.15)

The collaborative learning evident in this class, with a cohort of approximately 120, is quite different from the teaching approach adopted by Adam with six students. Both were revision sessions before the final end of semester exams, but students' active involvement in Bernice's session was in clear contrast to the students in Adam's session.

The practice of giving formative and summative feedback enables students to see writing as a practice that can be developed and improved; this is seen by Bernice as part of the purpose of requiring students to write two reports in her subject, in addition to the class quizzes (which also provide formative feedback). Each report is marked (some by Bernice and some by the tutors in the subject) and given written feedback which relates to the assessment criteria. She comments that the quality of the reports improves throughout the semester, noting that part of the improvement is probably due to the feedback and partly due to students having a clearer understanding of her expectations: 'But I think by the second one I've made expectations a bit clearer as well so it's probably a combination of the two'.

Bernice's sayings make connections between the writing practices in her subject and the engineering communication subject that all students would have completed previously, enabling students to see the developmental nature of such practices:

I give them a bit of general whole class type feedback which is along the lines of well a lot of people are still having problems with referencing, I know when you did [the engineering communication subject] you learnt about it, make sure you do remember. (Bernice interview)

Making these connections explicit allows students to understand that writing runs throughout their engineering degree, and that they are expected to use the knowledge they acquired in a previous subject to build their writing practices. Bernice's site provides intersubjective spaces for students to practise writing, but that space does not appear to extend beyond her site of practice. She does not see her practices as part of a continuum of practice to develop students' writing practices, and instead notes that many of her colleagues have the view that, 'It's more the subjects are atomistic and I'm responsible for the content knowledge development in my subject and not for all these other global skills' (Bernice interview).

Bernice comments that in other subjects in the engineering degree programs, students are required to write reports but the development of writing is not included in the learning outcomes, or the subject coordinators put an emphasis on calculations: 'It's about doing the calculations, it's not flagged as 'this is also an opportunity to learn to write as a practising whatever type of engineer you're planning to become'' (Bernice interview). Bernice's summation provides an encapsulation of how particular practice architectures of teaching enable or constrain particular practice architectures of student learning: In Bernice's subject, students learn to write as a way of demonstrating their understanding, of demonstrating the implications of their calculations, of interpreting their numbers and evaluating what the numbers mean. The practice architectures of Bernice's site of practice, which emerge through her sayings, doings and relatings, support the practice of learning, and become practice architectures for her students' learning through their writing practices, but the students' own learning practices (influenced by the practice structures of the school/faculty which put emphasis on marks rather than on learning outcomes) may constrain this learning.

4.4.3 Case study: Damien

Damien is a lecturer in the school of integrated engineering at University B and has been an engineering educator for some years, with prior experience in industry. This school belongs to a discipline of engineering that has a common curriculum shared by several Australian universities for years 3 and 4 of the Bachelor degree. He teaches a second year subject in integrated engineering. The cohort size is approximately 80 students. 'On successful completion of the [subject], a student should be capable of articulating the various elements of an integrated project and determine the potential size of an orebody' (Damien subject outline 2014 p. 2). The assessment tasks for this subject are: two numerical reports worth 20% and 5%, two field reports worth 15% and 30% each and a final examination worth 30% (Damien subject outline 2014, p. 7). The first field report is preliminary, to provide students with formative feedback. The second report is based on the first one.

There are four learning outcomes of Damien's subject; the fourth one states: 'students are expected to be able to...prepare a technical report that presents the results of a study on an integrated project that is consistent with the requirements and standards of the School of Integrated Engineering and relevant professional society' (Damien's subject outline 2014, p. 3). The practice architectures and practices of Damien's site interact to provide extensive support for writing practices within and beyond this site. Most striking is the report writing guide (RWG), used by all the Australian engineering faculties sharing the common curriculum of the integrated engineering discipline, and to which Damien has made significant contributions. It is a substantial document (84 pages) which provides extensive information about the field-specific requirements of engineering reports in terms of content, format, language and presentation, with exemplars, and was in its ninth edition at the time of this study. The existence of the RWG prefigures the perception by students and staff that writing is a practice, and that writing reports is an integral practice in the discipline of integrated engineering. The practice of revising the RWG demonstrates that writing practices are developmental and emergent, not fixed (unlike much of the propositional knowledge?). None of the other case studies in this research has an artefact like the RWG; at best there are learning guides or assignment guidelines which are specific to the subject and which would probably fall into disuse if the subject coordinator moved on to another subject or to another institution.

The cultural-discursive arrangements of Damien's site support his sayings about the relevance of writing practices to the study of integrated engineering. The subject outline includes assessment criteria for the assignments which specifically mention

‘Interpretation of information and calculations’ and ‘Discussion and demonstration of further research’ (Damien subject outline 2014, p. 9). Damien comments on the development of students’ writing practices within the school of integrated engineering and beyond his site of practice. In response to the question ‘How do your students learn or acquire engineering writing practices?’, he replies: ‘There is the report writing guide and then there is the practice in terms of writing reports throughout the – in the different [subjects] throughout the years’ (Damien, interview). The practices include a lecture given to all first year students enrolled in the school of integrated engineering and the RWG.

> *…we provide them [the students] with a copy of the report guideline and I give a lecture on why it’s important and what are the elements they need to be aware of when they’re writing reports. So right from the day one when they enter university we provide them with this.* (Damien, interview)

Writing practices in this site are supported by material-economic arrangements such as the artefact of the RWG and the doings of Damien and of the students. Two of the assessment items in Damien’s subject require students to write reports that require them to discuss and interpret observations or results. Report writing is practised and scaffolded in Damien’s subject and is developed through the major in which his subject is situated. Students receive explicit information about what is required in the writing of the report (with exemplars in the guide) and formative feedback. They also have the opportunity to practise their writing, both with the preliminary report ‘The idea of the preliminary report is for the students to have two turns at writing the report’ (Damien interview) and through an open-access online report writing site (University of Sydney 2012) with self-paced activities which features an engineering field report. The preliminary field report is given formative feedback, which can then be used for the second report. Damien introduced the scaffolding of the report at the suggestion of an ALL colleague at his university, with whom he has collaborated on several engineering writing projects.

Damien refers to the ‘cycle’ of report writing that the students experience as they progress through their degree, and outlines the writing workshops that he runs for fourth year students who are doing their honours thesis, as the following comment illustrates:

> *So they're constantly practising these skills because they're not going to write – after one cycle they're not going to necessarily be able to write a good report the second time round. It takes a lot of feedback – and feedback's important for students – for the students to understand their weaknesses and where they can improve in the future. Even introducing the first year, by the time they get to the fourth year it doesn't necessarily mean they can write good reports.* (Damien, interview)

The social-political arrangements and relatings in Damien's site of practice are notable; the presence of the common curriculum amongst engineering faculties in different universities is both unusual in the case studies and quite powerful in the way that it holds certain practices, such as report writing, in place. Damien's collaborations with his ALL colleague also influence the practices in his site and within his school; in addition to making contributions to the RWG, the ALL colleague gives a guest lecture on writing literature reviews to fourth year students in integrated engineering, enabling students to see writing as a developmental practice that requires a level of expertise. As is discussed in more detail in Chapter 6, academic language and learning support is available in various forms at all the universities involved in this study, but only Harry, Damien and Ivan say that they have consulted with ALL lecturers at their respective institutions, and only Damien has collaborated extensively.

In Damien's site of practice, the practice architectures enable writing practices that are developed and supported in a field-specific context and throughout a degree program. However, the students practise writing in a narrow range of genres, and learn writing practices for their exchange value rather than for their use value (Williams 2012). Damien sees writing skills as providing a competitive edge in industry, rather than as a way of learning, as shown in the following comment about graduates with poor writing skills: '…those who had difficulty in putting a report together, it reflected badly on their performance in the organisation and put them behind in terms of the standing with the others. Because it's basically a competition' (Damien, interview). For him, writing is primarily a way of enhancing students' competitiveness in the workplace. The project of writing practices in Damien's site of practice is to produce graduates with a competitive edge because of their enhanced report writing skills, not necessarily to produce graduates who can write to argue, question, justify, or challenge. This differs from the projects of Bernice's and Harry's sites, where writing practices are a way of learning by doing and a means to demonstrate critical thinking. For Bernice in particular, enabling students to practise writing in the context of engineering is a way of helping them develop as professionals:

> *I have these specific learning outcomes that I've got to address in my subject but I'm also conscious of the students' development as a whole professional and as a professional myself if I can help another developing professional develop then I think it's part of my responsibility to do that.* (Bernice interview)

Damien's site of practice provides strong 'working conditions' (Goodyear, Casey & Kirk 2016) for students to learn to write reports in the context of the field of knowledge (integrated engineering). It can be seen in this analysis that the cultural-discursive arrangements interact with the material-economic and social-political arrangements, and with the elements of practices (sayings, doings and relatings) to enable the practice and development of students' learning of writing engineering reports. On the other hand, the range of writing skills is narrowly prescribed and defined as report writing, so graduates from this school may be well equipped to write integrated engineering reports, but their proficiency in other types of writing could be less developed.

4.4.4 Summary of analysis of Group 2 practices

In this analysis, each case study has a different practice landscape; the practice architectures and practices identified in Table 4.3 interact in slightly different ways to provide support for writing practices in each site of practice. One reason for this might be the habitus of each of the participants in this group. As explained by Kemmis, Wilkinson & Edwards-Groves:

> The…habitus which practitioners bring to a site is crucial…Human beings inhabit practices – bringing their individual and professional histories and dispositions to the work of perceiving, interpreting and differentially enacting and realising or challenging or resisting the projects of different practices. (2017, p. 249)

The recognition of the role that writing practices plays in preparing students ‘for their life as an engineer’ and in the daily practices of a professional engineer, and how this is woven into the practices of Bernice, Harry and Damien seems to come back to their habitus, and how they have chosen to incorporate writing practices as part of the teaching and learning in their engineering subjects. The histories and dispositions of Bernice, Harry and Damien inhabit their practices so that writing practices are enacted as part of what it is to be, or to learn to be, an engineer

In Bernice’s case study, students are enabled to practise writing as part of learning the propositional knowledge and to see how this connects to what they learned in a prior subject on engineering communication, but there is no visible connection beyond Bernice’s site. In Harry’s case study, students are enabled to develop their writing practices within Harry’s subject and beyond to the other subjects in the stream of designing electronic circuits. Damien’s case study reveals a niche where an ecology of practices allows writing practices to be supported throughout a school of engineering and perhaps across engineering schools in other universities, but only as ‘report writing skills’ (it is not known how the schools of integrated engineering in other Australian institutions develop students’ writing practices prior to years 3 and 4 of the common curriculum).

4.5 Conclusion

Writing practices can be supported beyond a site of practice but the conditions which support these practices are not commonly found in the practice landscapes of engineering faculties (an ecology of practices to support writing practices has not been found to go beyond a school or discipline). To refer back to Mahon and Galloway’s ‘factors related to practitioner capacities’ (2017, p. 187), the ‘practitioner capacities’ of the participants in the current study to support writing practices cover a broad range.

The capacities are part of ‘a complex combination of factors’ (2017, p. 187), but appear to have significant impact on what happens within the sites of practice, if not beyond.

In a site of practice when the cultural-discursive arrangements do not mention writing practices as part of being a professional engineer, when the material-economic arrangements do not include writing in class or in assignments, when the social-political arrangements do not value writing in assessment weighting or do not value the ability to write well, writing practices are unsupported. When these practice architectures run across sites of practice, an ecology of practices can be seen that starves or ‘suffocates’ writing practices. At the same time as the development of writing practices is being starved, the development of propositional knowledge is nourished. It appears that many engineering educators within engineering faculties regard propositional knowledge and writing practices as competing with one another within the engineering curriculum: competing for time, for assessment weighting, for value, for importance. Whether or not this is a valid argument, it is clear that writing practices in several sites of practice in this study are neglected at the expense of supporting the acquisition of propositional knowledge. Although this is a small qualitative study, considering the literature (e.g. Howard, Khosronejad & Calvo 2016; Male, Bush & Chapman 2009; Mort & Drury 2012) the prevailing practice of suffocating writing practices could be said to exist within the Australian engineering curriculum at large.

It could be claimed that it is not possible to have an ecology of practices that supports writing practices in the engineering curriculum; that such an ecology is so alien to the practice landscape of the Australian engineering curriculum that it is unsustainable – the conditions simply do not exist that can support writing practices beyond a local site. In seven of the case studies on which this research is based this appears to be the prevailing situation, but Harry’s case study shows writing practices being supported through a disciplinary stream. Furthermore, the ecology of practices in Damien’s site of practice supports writing practices within the site of practice and beyond, so that students enrolled in the integrated engineering program practise writing from first year to fourth year as part of their engineering studies. The ecology of practices is established through Damien and colleagues’ educational research and evaluation (9th edition of the RWG for integrated engineers), through his professional development and learning (e.g. a journal article on use of peer review for integrated engineering students), through his educational leadership (leadership roles in his school, membership of the professional engineering association which oversees the common curriculum, writer of report writing guide), his teaching practices (subject outline, interview comments, assignment support documents) and students' academic and social practices (scaffolded writing tasks with formative feedback for field reports).

On the one hand, Damien's case study demonstrates that a niche can be created for an ecology of practices to nourish writing practices in the engineering curriculum. On the other hand, it appears to require exceptional pre-conditions to establish such a niche, and there is still no guarantee that this ecology will survive when Damien leaves the institution.

The following chapter (Chapter 5) argues that the practice architectures of the engineering curriculum interact with the dominant narrative of engineering education to hold in place practices which construct writing practices as other in the engineering curriculum. The consequence is that engineering knowledge and writing knowledge are seen as inhabiting two different worlds; co-existence is possible but not regarded as necessary.

Chapter 5
The Otherness of Writing in the Engineering Curriculum

… the maintenance of normativity is a fundamental fact about human life

(Schatzki 2012, p. 22)

Preamble

This chapter has been a difficult one to write, both in terms of its subject matter and its location in the dissertation. At first the notion of the otherness of writing in engineering was one I tried to avoid exploring, as it was taking me into uncharted territory, and forcing me to consider other ideas such as the gendered nature of writing in engineering – a fascinating realm, but well outside the scope of this thesis, and of my comfort zone. Ultimately, after several drafts and revisions, I made the decision to keep this chapter, to position it as emerging from the data analysis of unsupported writing practices, and as contributing to the invisibility of writing practices in the engineering curriculum. Consequently, the chapter begins with literature around otherness and how the otherness of writing in engineering is constructed through the practice architectures of the engineering identity and the engineering curriculum. As the concept of the otherness of writing in the engineering curriculum arose from the data analysis, the literature is included in this chapter rather than in Chapter 2. While I acknowledge that this is not the conventional positioning of literature about theoretical concepts, I felt that to move the preliminary discussion of otherness into an earlier chapter would place unreasonable demands on the working memory of the readers of this dissertation.

Overview

Chapter 5 (this chapter) is the second of three chapters which discuss the research findings. This chapter explores the notion which emerged from the data analysis that the prevailing practices of the engineering curriculum constrain the development of writing practices in part because writing practices are othered. Chapter 4 argued that the practice architectures of the engineering curriculum interact to enable the development of engineering students' technical knowledge at the expense of developing writing practices – that the development of technical knowledge competes for resources of time and curriculum space with the development of writing practices, and thus writing practices are constrained. These practices can be seen to occur because writing is seen as separate from technical knowledge.

However, as I continued to analyse the data and consider the research questions, it became clear that there was an undercurrent of emotional responses to writing practices which went beyond regarding them as getting in the way of the acquisition of technical knowledge. It was most noticeable in the doings and sayings – writing practices were not just ignored, they were often actively rejected, or spoken of as not belonging in the engineering curriculum. This realisation led me to investigate the idea that writing practices might be othered in the practice landscape of engineering education. In this chapter I argue that that the construction of the 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 (Muller 2009) contribute to the otherness of writing practices. These practices construct writing practices as other and place them outside the frame of what is thinkable as engineering practice for engineering educators.

This chapter begins by introducing the concept of otherness, before exploring aspects of the engineering identity and of the engineering curriculum which together construct writing practices as other in the engineering curriculum. The prevailing narratives of engineering as being about ‘doing’, and of the engineering curriculum as a writing-free zone thus interact to obscure the writing practices that are an integral component of engineering practice. Analysis of the participants’ sites of practice shows evidence of practices that other writing. There are also sites of practice which do not other writing, and which enable writing to be practised as part of what and how the students learn; I discuss why some practitioners normalise writing practices as part of engineering studies. The chapter concludes by reviewing the practices which do or do not other writing and speculating on how practices might shift to normalise writing as part of learning engineering.

5.1 Introduction

This chapter introduces the concept of the 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 for engineering students 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 & 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 as negotiation is not what engineers do. The following section explores the notion of the otherness of writing in the engineering curriculum.

5.2 The concept of otherness

The perspective of the otherness of writing practices in the engineering curriculum is a somewhat novel one, and was not apparent to me until I began to see a pattern: writing interventions that are introduced into the curriculum but are 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' (e.g.

Goldsmith & Willey 2016b; 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 technical or propositional knowledge 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' (Zevallos 2011). The establishment of in-groups and out-groups depends on an asymmetrical power relationship, where the dominant group can establish its identity as valuable and deny the value of the out-group; the out-group is seen to lack the necessary identity to belong to the in-group, thus establishing Otherness (Staszak 2008). The dominant group constructs anything that differs from the mainstream as other; minority cultural groups, colonised peoples, women – all have been constructed in various contexts as somehow outside the norm, and of being seen as different or strange. Researchers have identified various ways of othering (Bhabha 1983; Brons 2015; Zevallos 2011) by the dominant group, including:

- refusing or being unable to see similarities between itself and the other group (Barnhill 2010)
- stereotyping and stigmatising
- viewing the Other as homogenous – making generalisations that do not recognise diversity in the group
- devaluing the Other

- rendering the out-group invisible by 'inability or refusal to recognize their actual existence' (Barnhill 2010)

Why engineering education constructs writing as other cannot be determined conclusively. An in-depth exploration of engineering culture is beyond the scope of this thesis, and has moreover been ably conducted by other researchers (e.g. Godfrey 2009; Downey & Lucena 2003; Hacker 1989; Wajcman 2010). The dominance of engineering culture as predominantly white, masculine, rationalist and technological provides some context, setting up a binary with cultural diversity, femininity and emotion. In addition, the post WWII shift to the engineering science curriculum may have generated a more scientific identity for engineers; this identity then needed to emphasise precision and accuracy, and disassociate itself from the speculative, imprecise elements associated with engineering practice such as design and discursive writing (c.f. Downey & Lucena 2003 for their discussion of how engineering design is othered in the engineering science curriculum).

To understand how the otherness of writing practices is constructed in the engineering curriculum it is therefore useful to see how the engineering identity and the engineering science curriculum contribute to this construction. The following section discusses some ideas of engineering identity, in addition to considering how engineers view the knowledge of their discipline and the knowledge of writing practices.

5.2.1 Engineering identity through the eyes of engineering educators

The definitions and narratives that engineering educators construct about engineering and about themselves are part of the practice architectures that prefigure practices within the engineering curriculum and within the sites of practice of engineering educators. These narratives 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 et al. 2009; Trevelyan 2010) rather than as those who pose, frame and challenge the nature and type of problems. The image of an engineer as an articulate, literate member of society who challenges orthodoxy and asks uncomfortable questions is thereby constrained. 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. A significant factor about the construction of the engineer as technical specialist is that it has arguably been created by engineering educators who are themselves technical specialists. A substantial majority of engineering educators have no or minimal industry background, with many progressing straight from their PhD studies to a job in an engineering faculty with a major focus on research. They may thus lack an understanding of engineering practice in practice, and of the many roles that writing plays in the everyday work of a professional engineer (Trevelyan 2007, 2009, 2010).

Several authors note the role that mathematics plays in the creation of the engineering identity (e.g. Faulkner & Herman 2016; Hacker 1989; Lee & Taylor 1996), 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. 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 5.4.2). 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. Furthermore, the language of mathematics does not have the range of communicative functions that other languages have; as Godfrey and Parker accurately observe, it can be used for ‘knowledge transmission’ of mathematical ideas (2010), but cannot be used for extended writing. This implies 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.

Pawley emphasises the significance that mathematics has for engineering educators to delineate what engineering is: ‘[m]ath 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). 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. 4) 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 doing assessment tasks and marking them, respectively, and just as often losing that competition (e.g. Wheeler & McDonald 2000; Goldsmith, Willey & Boud 2012).

In addition, 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 1989, 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. The construction of the engineering identity as solitary, masculine and technically expert shapes and is shaped by engineering educators – not by all, but it is the dominant identity. This construction then impacts the formation of the student engineering identity, as discussed in the following section. As with many aspects of pervasive practices, it is difficult to pinpoint the boundaries of practices and their influences, but the shaping of the student engineering identity in the image of the dominant engineering identity has been identified by several researchers (Hacker 1989; Tonso 2006; Walker 2001).

5.2.2 Student engineering identity

Studies of student engineering identities reveal strikingly similar images of technical expertise and limited social skills – referred to as 'the traditional stereotype of the asocial geek' (Wulf & Fisher 2002, p. 36). A student's perspective on engineering identity, and one which sees othering of those who do not conform to the dominant model, is provided by Karen Tonso (2006), who conducted a study of how engineering students form their practitioner identities. Her study, based on a US engineering school, reveals a male-dominated culture where students who did not fit the images of an engineer as constructed by the campus were othered (2006, p. 295). Tonso notes that the campus engineer identities emphasised engineering science, which she terms 'academic science', and a masculine culture. 'In particular, the organization of campus engineer identities indicated the prestige of academic-science and the status of male-identified ways of life' (2006, p. 298). Her observations about the 'male-identified ways of life' and the focus on engineering science with its intense workload reinforce those of Hacker (1989), in Walker's study of male and female engineering students in the United Kingdom (2001) and in Godfrey and Parker's study of engineering culture (2010). They also align with Lee and Taylor's feminist critique of engineering education (1996), where the authors seek to 'make the culture of engineering "other" and to expose it as a project of the formation of historically specific masculine identities' (1996, p. 60). The authors comment that despite the post-industrial shift in engineering from making things to information management, the teaching of engineering still places great emphasis ‘on the physical manipulation of technologies’ (p. 64) which is seen and defined as part of the formation of masculinity.

The masculine qualities of the engineering identity contrast with qualities that are seen as desirable by employers and are often termed professional attributes: team-building, intercultural competence, and strong oral and written communication skills (Walker 2001). Tellingly, Walker notes: ‘…these qualities are often characterised as feminine areas where girls and women are assumed to be more capable than boys and men’ (2001, p. 78). One reason behind the otherness of writing practices in the engineering curriculum may be a gendered view of writing – that it is regarded more as a feminine than a masculine domain. Walker’s observation about qualities such as oral and written communication being seen as ‘feminine areas’ is borne out by Mallette’s research on gender and writing in engineering. Mallette refers to ‘the gendered nature of writing labor in engineering’ (2017a, p. 1) ‘Historically in engineering settings, women were denied access to field work and other spheres where “real” engineering work occurred, yet they were able to be involved with the communication of technical information’ (2017a, p. 3), and argues that the labour of writing is less valued than the labour of design work.

The focus on engineering science, notably advanced mathematics, with its intense workload as part of the student engineering identity, matches Hacker’s experiences (1989) and is commented on by Stevens and colleagues (Stevens et al. 2008). Seymour and Hewitt observed that the ‘weeding out culture’ is more pronounced in the engineering curriculum than in other STEM disciplines (1997). Tonso comments that the dominant student engineering identity is so constraining that ‘[s]tudents more likely to perform creative visions of engineer were also less likely to be thought of as engineers who should be part of determining what ‘real’ engineering might be’ (2006, p. 300). These constraints contribute to the student engineering identity which aligns with the similarly constrained narratives of the engineer as illuminated by Pawley’s study; both the student and the engineering educator identity enable engineers to think of themselves as highly trained technical experts. At the same time, these identities constrain the idea of the engineer as creative or as likely to challenge the status quo. None of the dominant images of engineers identified in these studies includes engineering educators or student engineers engaging in debates and discussions, or writing justifications and recommendations as part of their daily work.

In the formation of the identity of the engineering educator and of the engineering student, othering of writing (and of writing practices) occurs by making writing practices invisible, by seeing them as outside the boundaries of engineering studies, by devaluing them, and by characterising writing practices as feminine. The feminising of writing practices in engineering studies could be called a 'double othering', as women are still frequently seen as outsiders in engineering contexts (for a detailed analysis of technicist versus heterogeneous identities in engineering see Faulkner 2007).

Although this is the dominant narrative of the engineering identity, there are dissenting views which have emerged in the literature over several decades. In addition to the feminist critiques of engineering education made by Hacker (1989) and others, the perception of the engineer as working on technical solutions in isolation like a technologically schooled Lone Ranger has been questioned by several authors, some of whom are themselves engineering educators. Johnston, Lee and McGregor (1996) refer to the current captivity of engineering education and practice, arguing for the need to emphasise the socially responsible aspects of engineering and to expand the discourse; Lee and Taylor (1996) portray contemporary engineering education as one which regulates and drills engineering students to have great technical competence but a profound unwillingness or inability to question 'why or whether certain technologies should be developed or certain projects should be pursued' (1996, p. 67). Trevelyan (2010) reports that '[n]early all the literature on engineering education and practice reveals an overwhelming belief that engineering is all about solitary technical work' (2010, p. 384), despite research on engineering practice which shows the prevalence of collaboration, coordination and communication (Trevelyan 2007). He argues that engineering could work much better if it had 'an identity in which the social and technical embrace each other with equal prominence' (2009, p. 1). Such an identity could also incorporate the image of engineers who can write, and write well, to convey their ideas, to argue for or against particular courses of action, or government policies, and who could be regarded as makers of opinions as well as 'makers of things'. Despite the arguments for engineering education to develop a literate engineer, there is significant resistance within engineering to adopt this viewpoint. The following section discusses how a writing identity is seen as other in the context of engineering.

5.2.3 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 2006; 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'. It is not the intention of this thesis to unravel all the threads which create the engineering identity, but it can be seen that 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’ (1996, 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 5.4.2 of this chapter. 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.

The somewhat uneasy relationship between engineering and writing has been explored in several studies, but 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). However, despite the perception that engineers have of themselves as people who work with objects, ‘writing is what engineers do’ (p. 68). 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 – for them and for engineers, knowledge is constructed through texts, and the objective of lab activity is inscription (1986, p. 48) – the conversion of physical reality into written documents. Yet the members of the scientific laboratory were angry at being portrayed as participants in some literary activity: ‘In the first place, this failed to distinguish them from any other writers. Secondly, they felt that the important point was that they were writing *about* something, and that this something was “neuroendocrinology”’ (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). Winsor concludes that engineers inhabit a world of language, just like everyone else, but are more resistant to the idea that language mediates experience. Although engineers do not acknowledge or recognise the use of rhetoric in their writing because of the belief that engineering is about 'objectivity', Winsor argues that in fact 'persuasiveness…is built into the very goal of engineering' (1996, p. 11). On the one hand, 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. On the other hand, engineers understand implicitly (possibly more than others) about presenting the right data to fit the circumstances; thus there is some recognition of the 'persuasiveness' inherent in the discipline – this method or approach rather than that, to suit the budget, the stakeholder requirements, the physical and logistical constraints of the problem. 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). In these examples, the othering occurs both through devaluing writing practices – 'a quasi-clerical chore' (Nagle 1996, p. 6) – and by making them invisible, by not acknowledging that writing is anything more than assembling facts.

The engineering identity which thus emerges from the literature resembles Schon's 'technical rationalist', the instrumental problem-solver rigorously applying scientific theory (1983, p. 21), 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. In summary, the construction of the engineering identity others writing (and of writing practices) by making writing practices invisible, by seeing them as outside the boundaries of engineering studies, by devaluing them, and by characterising writing practices as feminine. The feminising of writing practices in engineering studies could be called a 'double othering', as women are still frequently seen as outsiders in engineering contexts (for more detailed analyses of male and female identities in engineering see Faulkner 2007; Hacker 1989; Wajcman 2010; Walker 2001).

The next section discusses the predominant view that engineering science represents engineering knowledge in the engineering curriculum, and considers how this contributes to the otherness of writing practices.

5.3 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 et al. 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 working out 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 et al. 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 assessment 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). As discussed in Chapter 2, Section 2.3, engineering is classified as a knowledge code in the LCT literature. Writing practices are highly contextualised and situated so they are more likely to be classified as a knower code, along the lines of literary studies and secondary school English (Howard & Maton 2011; 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 5.4 of this chapter. It may be that engineering educators in general share this perception, and therefore do not see that writing is a practice; rather it is a disposition, or a skill, or an activity. This suggests that many engineering educators see writing practices as akin to the study of English literature – 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 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 (Mallette 2017a, 2017b), which certainly conflicts with the dominant engineering identity, and with the types of knowledge that are highly valued in the engineering curriculum.

To sum up, the prevailing engineering identity, associated with masculine qualities and technical competence, interacts with the belief that engineering science is the core of the engineering curriculum, and which sees writing as separate from engineering and as a different kind of knowledge. These perspectives work together to other writing practices, often by refusing to recognise their existence in an engineering context, through devaluing them as a soft skill, and by implicit associations with feminine attributes.

The above discussion has considered how the practices of engineering education contribute to the otherness of writing practices in the engineering curriculum. The following sections consider evidence from the participants' sites of practice of practices which do, or do not, other writing practices, and discuss the implications of these practices.

5.4 Othering practices in the sites of practice

The practice architectures of the engineering curriculum, combined with the dominant narrative of engineering education, 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 explore othering practices of writing 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 possible to ascertain why these practices may have arisen. Practices that do not other writing are also analysed; the discussion explores the elements of practices which enable writing practices to be regarded as part of the learning of the subjects. The othering practices have been characterised as follows: *the emotional dimension of writing compared to other types of knowledge; writing practices that have many names; writing practices that are excluded from the site of practice.*

5.4.1 The emotional dimension of writing practices

Othering practices tend to be demonstrated mainly in discourse, but reflect the social, political and economic power of the speakers (Staszak 2008, p. 3). Cultural-discursive arrangements and sayings are therefore the location of much of the evidence of othering in the participants' practices. 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 language used by the participants to talk about their own and their students' writing practices reveals an emotional dimension that writing practices occupies for some of the participants. The emotional dimension, or affective domain, surfaces in the emotive language of their sayings when they talk about writing and writing practices, and was extracted from the interview data using concordance software (Watts 2011). Examples of emotive language or the language of affect are words that describe feelings or that express emotions, such as love, hate, dreadful, embarrassing (see Table 5.1 for examples from the participants' sayings). This language is used to talk about their students' writing practices and the participant's own writing practices as engineers; it 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 5.1, and are contrasted with the affectless terms used by the participants to describe the propositional knowledge in their engineering subjects. The terms were extracted from the data using concordance software (Watt 2011) and then checked for context to ensure that they were referring to the participants’ feelings about writing practices.

Table 5.1: 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 assessment 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 strongly on the production of a written artefact of substantial length. The honours thesis or capstone report can be 50-100 pages (University of Technology Sydney 2017), 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 major 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. The lack of acknowledgement of the developmental nature of writing practices has at least two consequences; it reinforces the belief that writing is a context-independent skill rather than a practice, and it perpetuates 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 the following response:

…So they haven't actually done the sort of engineering thing which is you do a whole load of analyses and you vary your parameters and then you see what happens and then you kind of demonstrate you understood what happened. That's novel to them. 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 cast writing practices as 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. Furthermore, the assessment weighting of the written assignment is in a losing competition with the assessment weightings for the quizzes and exam. The conflicts that emerge from his site of practice suggest that for him, writing occupies a very different territory from that of propositional knowledge.

5.4.2 Writing practices that have many names

In addition to the affect terms used to speak about writing practices, a striking feature of the sayings of the participants was the range of terms used for writing and writing practices. The following paragraphs 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. The most notable 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; yet the majority of the participants refer to English, and English has many meanings. These have been summarised in Table 5.2, 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 ('It reminds us of Miss Thistlebottom's 8th grade English class, in which we were bombarded with now-forgotten rules of grammar'): 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 as 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 5.2: 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 second 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; this is very interesting because I hated English at school	English as correct grammar; 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 (1996) representation of what writing means to engineers 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. Meta-language is the language used to talk about language – the terminology for the structure of a text, or for the functions of parts of speech. As Fischer 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… (2015, 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. One example of this is in Adam's subject. 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 study (2015), 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.

In the case study analyses, most of the participants did not demonstrate familiarity with ways of talking about writing practices, as indicated in the examples of Adam and Ivan. In Felicity's case study, her inability to talk about writing practices or to see the absence of writing practices in her subject suggests both a lack of meta-language and a case of knowledge-blindness (Silverman 2009). As an expert, she cannot see what it is like for novices to learn the practices of report writing, perhaps because her own learning of these practices was some time ago, and tacit rather than explicit. In another case study it was clear that 'flowery' language, associated with 'high school writing' was not acceptable:

- *…you see this in the language. Sometimes it is bombastic and flowery, which is what they learn to write in assignments in probably high school* (Charlie interview)

Charlie can see that the students are not familiar with the style of writing expected of them in a reflective report. However, despite the extensive instructions given to students in the subject documentation, there was no example of what style of writing would be more appropriate than the apparently purple prose some students are producing.

Three of the case studies provided examples of meta-language about writing. In his interview, Harry differentiates between elements such as formatting, 'defence force style' and 'non-essay-style' writing and expression but needs to be prompted on some of this. Bernice has a clear understanding of writing practices and the language with which to communicate it, as can be seen from the following comments:

- *There has to be – or I'm looking for a logic chain in their discussion particularly in the report…*
- *There's also the mechanical issues of writing like spelling, punctuation, grammar, appropriate referencing* (Bernice interview)

Her sayings show that she has the language to explain to students the difference between logical connections in a text (structure) and the mechanics of writing (surface features of language). Damien's teaching practices to develop his students' writing practices are supported by his collaboration with an ALL lecturer at his university; this influence can be seen in the information about report style as provided in the report writing guide for integrated engineering.

Figure 5.1: Report style as listed in table of contents Integrated Engineering Report Writing Guide 2014, p. v

Figure 5.1 is taken from the table of contents of Damien's report writing guide (which he co-authored with the ALL lecturer with whom he collaborates), and lists the elements of report writing style that students need to be familiar with; explanations and examples are provided in the guide so that students can see what each term means. It can be assumed that the section on report style was written by or informed by the knowledge of the ALL lecturer. As noted elsewhere, Damien's recognition of the expertise of the ALL lecturer and a willingness to collaborate with her demonstrates an awareness that writing is both a practice and an area of knowledge in which he is not necessarily an expert.

5.4.3 Writing practices that are excluded from the site of practice

The practice architectures and practices that interact to exclude writing practices from an engineering subject construct a view that writing practices are outside the domain of the site of practice. Thus, writing practices may not be seen as part of the knowledge that the students need to acquire in the participant's subject, nor as a way of developing their learning. Engineering educators may exclude writing practices from their subjects, except for the practice of notations, calculations, short answer tests and form-filling. This can be seen in Felicity's site of practice. The assessment tasks in Felicity's subject include computer lab assignments and group projects with individual components, yet there are no writing practices beyond completing templates for a project and making notations. Felicity comments that students do not need to write in this subject:

> *Interviewer: How do you – the writing practices in your subject prepare the students for the writing practices of engineering?*
>
> *Felicity: For this unit they do not need to write too much. So we don't deal with this case.* (Felicity interview)

The separation of writing practices from propositional knowledge, which reinforces the otherness of writing, can be linked to the institutional or faculty practice of outsourcing the development of writing. Depending on the institution, this can be generic workshops run by student support services, ad hoc referrals to remedial consultations with academic literacy specialists or a communications subject within the faculty. This is reported in several of the interviews, and often the participants are not aware of the type or level of support available. The following comment by Felicity about the role of writing support for her subject within her institution shows the distance between developing writing and learning propositional knowledge:

> *actually they learn that also – we already have another unit [subject] which is run by the – I think – I'm not quite sure about the name of the unit, but for that unit they will learn how to prepare a report, how to write a report of their project or how to attempt each question of their assignment or other work.* (Felicity, interview)

When Felicity was asked whether the unit was specifically for engineering, she was unsure: 'No. This is for – I have no idea about the other disciplines but as far as I know yes, this is similar to other ones' (Felicity, University C). In other words, students are taught generic report writing in another subject and are expected to transfer that knowledge to the very specific domain of Felicity's subject. These practices consolidate the practice architectures that can be detected in many engineering subjects where writing or communication skills are seen as separate from technical knowledge.

Felicity's response suggests that she does not see these tasks as writing, or perhaps that the tasks are not connected to the writing practices of engineering. Felicity's case study is discussed in more detail in the previous chapter, in the context of unsupported writing practices, but it could be argued that the lack of support for writing practices in her site stems from the practice architectures in the engineering curriculum that position writing as other. These practices consolidate the practice architectures that can be detected in many engineering subjects where writing or communication skills are seen as separate from technical knowledge. Furthermore, what is *not* said is also part of the arrangements: if writing/communication is not listed as a subject or task learning outcome, it has no presence for the students. When this effect is multiplied over the majority of engineering subjects, the impact is strong and clear: engineering is about technical knowledge, and has little to do with communication.

5.5 Practices that do not other writing

Thus far I 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, yet all three sites of practice share elements that enable writing to be practised as part of students' learning. 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 (University of Sydney 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 evidenced in all three sites through the participants' sayings, doings and relatings. As discussed in Section 5.4.2, these three participants demonstrate varying levels of familiarity with the meta-language associated with writing practices, which means that they can give students explicit advice about how to improve their writing. The participants make constant reference to how they give feedback on students' writing, and the importance of feedback for learning. 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 these 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.

When the practices of Bernice, Damien and Harry are compared with those of other participants, several observable differences can be noted. 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 is their belief that writing consolidates learning, as the following 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:

- *I'm also conscious of the students' development as a whole professional* (Bernice)
- *...what part they will play as a graduate Engineer in the future* (Damien)
- *...we have only four years to take them from [a] rank beginner to people who can be employed as a professional engineer* (Harry)

These and similar comments are a recurring motif in their responses to interview questions, but are absent from the sayings of most of the other participants, with the exception of Charlie. The other participants comment on the learning that students acquire in their subjects, but not that they are preparing their students to become practising engineers.

In the sites of practice which normalise writing as part of learning to be an engineer, 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. Above all, the language used by these participants does not other writing practices; they speak of writing practices as being part of engineering, not as occupying a separate domain which is outside or unrelated to the learning of the engineering curriculum.

5.6 Conclusion

In this chapter I 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.

It is human nature to prefer the activities in which we excel and which are regarded by our peers as valuable, and to avoid the activities in which we do not succeed. It is therefore not surprising that many engineering educators, with their hard-won technical knowledge which provides membership of an elite, value this kind of knowledge and devalue the knowledge of writing practices. The practice architectures of the engineering curriculum polarise these two kinds of knowledge so that one cannot accommodate the other. Overall, these findings show that engineering academics have a different view of the value and nature of technical knowledge compared to their view of the value and nature of writing practices, consequently leading to tensions and contradictions in practices. It takes more than saying that writing is important; without the cultural-discursive arrangements, the material-economic arrangements and doings, and the social-political arrangements and relatings to support writing practices, they will not be developed and will continue to be seen as other.

Yet there are practices which include writing, and which demonstrate its role in the development of critical thinking, of professional identity, and of the ability to compete and succeed in industry. 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. Nevertheless, 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’ needs to be unpacked, and the importance of a shared meta-language about writing practices is not to be discounted.

The following chapter, Chapter 6, considers the ongoing invisibility of writing practices as a consequence of prevailing practices that render writing practices as other and which do not support writing practices in the engineering curriculum.

Chapter 6
The Invisibility of Writing Practices in the Engineering Curriculum

Overview

This chapter seeks to conceptualise and link the key findings in previous chapters by considering how writing practices are invisible in the engineering curriculum. Chapter 4 argued that prevailing practices in the engineering curriculum do not support writing practices; in the majority of the case studies, writing practices were unsupported, fragmented or were supported within the local site of practice but not beyond. Chapter 5 explored the idea that there was more than just a lack of support of writing practices in the engineering curriculum, and developed the notion of the otherness of writing in the engineering curriculum. In Chapters 4 and 5, the evidence showed that where writing practices have been put in place in a subject, changes such as a new subject coordinator or an increase in the number of students can work quickly to limit writing practices or to remove them from the subject. Unless there are existing practice architectures that hold writing practices in place, and/or individual engineering educators exercise considerable agency, writing is not practised. It may be reduced to notation, or subsumed within formatting and referencing as part of assessment criteria.

This chapter begins with the claim that the prevailing practices of *unsupported writing practices* (Chapter 4) and of *othering writing practices* (Chapter 5) interact to form practice architectures that render writing practices invisible in the engineering curriculum. The argument is as follows. The ecology of practices which 'starves' writing practices allows them to be overshadowed, overlooked or neglected. This causes writing practices to become less visible in the engineering curriculum, but not necessarily invisible. The othering of writing practices in the engineering curriculum leads to writing practices being not what is thought of as engineering knowledge; they become less thinkable, less doable and less relatable in engineering studies. Writing practices which are othered become less visible, but again, not necessarily invisible. It is the interaction between practices that do not support writing practices, and practices that other writing practices, which renders writing practices for the most part invisible in the engineering curriculum. In other words, where there is no support for a practice and where the practice is seen as other, that practice becomes to all intents and purposes invisible. Its invisibility then reinforces its outsider status.

The analysis of the case studies shows that writing practices are invisible in the engineering curriculum at course and subject levels and at an institutional (faculty) level. They are also less than visible at an individual level; engineering educators struggle to identify how they acquired their writing practices. Writing practices become visible in the engineering curriculum only when they cannot be avoided, such as when the stakes are too high, and that is mainly in the final (fourth) year of an engineering degree, when all students are required to complete either an honours thesis or capstone project. It is the point at which students and staff begin to 'take writing seriously'. The chapter concludes by arguing that the continued invisibility of writing practices in the engineering curriculum is the result of a complex interaction of practices. The disruption of these practices would need to involve changes in practices in policy and pedagogy – a shift in the practice architectures of the engineering curriculum both at a national and at a local level – a not impossible feat, but an unlikely one. Writing practices become visible as part of engineering knowledge when there is an explicit narrative of subjects woven through with writing practices, enacted through collegial relationships that see engineering knowledge as integrated rather than atomised. In other words, writing practices become visible when the practice architectures are there to hold them in place as part of learning to become an engineer.

6.1 Elements of invisibility

Briefly recapping from Chapter 2, Section 2.2, writing practices are often invisible in higher education because they are assumed to be part of common sense knowledge, and because language is regarded as a transparent vehicle for communication. In the engineering curriculum, the *practice* of writing practices is difficult to see; writing is mostly viewed as a skill. Aligned with the perspective of writing as other, these views combine to form practice architectures that prevent writing practices from being seen as part of the practices of engineering, or as developmental practices. Where they can be found in the engineering curriculum, they appear to staff and students as vexatious interruptions to the acquisition of engineering knowledge. The practice architectures of the engineering curriculum prefigure writing to be seen as ‘a set of atomised skills which students have to learn and which are then transferable to other contexts’ (Lea & Street 1998, p. 159), as discussed in Chapter 2. Thus writing is often not developed, nor is it seen as an area of knowledge that can or should be developed. Students may then gain an impression of writing as separate from ‘doing engineering’, a burdensome chore that is required of them by their academic studies and which with any luck will disappear once they become ‘real’ engineers.

This attitude is exemplified in the following student comments. The first is from a postgraduate engineering student complaining in a student satisfaction survey about the emphasis on critical analysis in a written assessment task: ‘I did not undertake a Concrete Technology and Practice subject to be assessed on the way I critically analyse information…’ (Gardner, Goldsmith & Vessalas 2016, p. 6). The second comment is taken from one of the interviews for this study, where the participant (Charlie, from University A) is talking about students pushing back when they are asked to write a lengthy report: ‘The comments I get from them is, “if I wanted to write I would take a degree in Arts”’ (Charlie, University A, interview, this study). These student comments illustrate a distaste for writing, an association of writing with an Arts degree (possibly the perceived antithesis of an engineering degree), and an underlying belief that technical knowledge is what they should be learning – that engineers do not need to write. One suspects that these students would heartily agree with Nagle’s observation that ‘writing is, for many of us, a bummer’ (1996, p. 6).

For these and for many other engineering students, writing practices are irrelevant in the engineering curriculum; they do not see what purpose writing serves in their studies; for the most part they do not see their teachers writing, nor are they shown examples of this writing – they do not see writing being practised and therefore they do not see it as a practice. This invisibility of practising writing must have profound impacts on what engineering students see as ‘the business’ or the practice of engineering, prior to their induction into the workplace and to the communication practices that take place there. Perhaps the impact is instrumental in maintaining the myth of the 'non-writing' engineering curriculum, reinforcing the (possibly cherished) belief that engineers don't need to write because they have such arcane technical knowledge (Trevelyan 2009, 2014).

Based on the analysis of the case studies which has informed the findings and discussion in Chapters 4 and 5, Table 6.1 summarises some of the practices and how they are characterised in PAT which prefigure (but do not predetermine) the invisibility of writing practices within several sites of practice.

Table 6.1: Practice architectures & practices that enable the invisibility of writing practices

Practices	Characteristics of PAT
A lack of meta-language with which to talk about writing practices; no feedback on written assignments	(sayings/cultural-discursive arrangements)
No opportunities for students to practise writing during classes	(doings/material-economic arrangements)
No time allocated to developing writing practices in class or for homework	(doings & relatings)
Minimal assessment weighting given to the quality of writing	(material-economic and social-political arrangements)
no intersubjective spaces for writing practices	(the practice architectures necessary to support a practice)
No observable agency on the part of the engineering educator to enact elements of practice that would enable students to practise writing	(habitus or disposition)
No visible links between one subject and the next, or between the writing practices developed within one subject and what might be practised or expected in subsequent subjects	(relatings and social-political arrangements)

When these practices and practice architectures interact, writing as a practice becomes invisible to engineering students. It will be viewed as the action of 'writing-up', rather than the process of refining and clarifying ideas and evaluations.

How this plays out in the sites of practice is illustrated in Table 6.2. The information on which the table has been constructed has been drawn firstly from the document analysis of subject outlines and assessment documents, and then checked with the participants during their interviews and in any follow-up emails. Table 6.2 lists the written assessment tasks in each case study, whether there is provision for formative assessment or feedback, whether the participants can see the development of students' writing practices from the beginning to the end of the semester (a specific interview question) and whether there are opportunities for students to practise writing in class or for homework (including online modules). The third column of the table provides information on whether the students receive formative assessment or feedback (either before or after submission) on their writing tasks. The terms formative assessment and feedback as used here are based on Sadler's definitions: 'Formative assessment is concerned with how judgments about the quality of student responses (performances, pieces, or works) can be used to shape and improve the student's competence' (1989, p. 120). Feedback is information regarding the level of success of a performance, but Sadler makes the important distinction based on Ramprasad's (1983) definition that 'information about the gap between actual and reference levels is considered as feedback *only when it is used to alter the gap'* (Sadler 1989, p. 121; emphasis in the original). Thus the comments in the third column of the table on feedback indicate where students are given information regarding their written assessment tasks that provides them with an opportunity to improve that task, either through discussions in labs, lectures and tutorials, lecturer and peer feedback on quizzes that are part of a larger assignment, or by resubmitting the assignment. If students are given summative marks and comments on their assignments with no chance of resubmission, this information is not functioning as feedback and has not been reported as such in the table.

Table 6.2: Summary of writing tasks and practices

Site	Written assessment tasks	Formative assessment and/or feedback Y/N	Visible development of writing practices Y/N	Writing practised in class or for homework Y/N
Adam	3 reports worth 60% of total assessment	N	N (gets worse)	N
Bernice	2 reports worth 40% of total assessment	Y No formative assessment but feedback given	Y (most)	Y in-class collaborative problem solving
Charlie	Reflective report worth 55% of total assessment	Y Formative + peer review	Y (only writing a reflective report)	Y
Damien	Scaffolded writing tasks; 4 reports worth 70% of total assessment	Y Formative* + summative	Y	Y online modules
Eric	3 group projects worth 65% total mark: 1st project is basis of 2nd project which is basis of 3rd project	Y Summative but feedback given on each stage of project	Y from 1st to final report	N
Felicity	Problem solving task 40% (group + individual component)	N	N	N
Garth	2 group projects worth 40% of total assessment (tasks don't match subject outline)	N	N	N
Harry	3 lab reports: 2 formative¤ + summative, 1 summative 20%	Y Formative¤ + summative	Y (not sure how to quantify)	N
Ivan	1 lab report 10%	N	N (no way)	Y online modules

*Formative is used in Damien's site to mean that students are required to complete a preliminary field report worth 15% of total marks and which is given feedback by markers. The preliminary report is the basis of the final field report which is worth 30% of total marks.
¤Formative is used in Harry's site to mean that the first two lab reports are graded satisfactory or unsatisfactory and are given feedback by the markers. The third lab report is expected to incorporate the feedback and is worth 20% of total marks.

An analysis of the information presented in Table 6.2 strongly suggests that the development of students' writing practices requires more than setting written assignments for assessment; without some kind of formative feedback, and the language with which to communicate it – meta-language about writing – there does not appear to be detectable improvement. The comments in column four of the table support this observation; the sites which have practices of feedback where students can learn and improve on their writing tasks are also the sites where participants can see development of student writing practices. The obverse is also the case. As discussed in Chapter 5, Section 5.4, the case studies of Bernice, Damien and Harry show the role of feedback in students' learning. In regard to being able to see the development of students' writing practices, Damien comments that he can see the difference between the writing practices of the students in his school and those who have articulated in from other schools of engineering in the engineering faculty of University B:

> *So, for example, we have an increasing proportion of students who come from the Civil Engineering stream who don't have that background. So when they get into our third year – equivalent of third year – they don't have the same sort of background in terms of what we do for our students in our first and second year, so they're behind.* (Damien interview)

The practices in Charlie's site of practice bear close scrutiny as an example of what might be called an 'engineering approach' to writing, where the requirements and specifications of the writing task are outlined in detail in order to remove uncertainty. In this case, students are required to write a reflective report after their internship. The report is worth 55% of the total marks for the subject and there are several opportunities for writing practice, so presumably students should be well supported in developing their writing practices. However, the assessment guidelines and checklists, contained in nine separate documents in addition to the 42-page learning guide, are bewilderingly complicated (see Figure 6.1 for an example of the 'tagging' of the items that students must include in their reports). It is as if writing practices are being treated as writing code (Charlie is a software engineer), or as though the potential for ambiguity that is inherent in writing discursively is being eliminated by specifications that demand precision, exactness and tagging (or coding). By specifying exactly what is required and where, the documents attempt to remove the risk of variable interpretations of a reflective report. Research indicates that engineering students tend to be risk averse (e.g. De Paola & Gioia 2012); their teachers may well share this tendency. In fact, part of the reason for the provision of detailed specifications is likely to be for the tutors who provide feedback and who mark the reflective reports.

Figure 6.1 is an extract from Charlie's learning guide and gives a glimpse of the effort Charlie has taken in his learning guide to make sure students (and tutors) know what they are supposed to do. It is interesting to note that Charlie classifies communication as a non-cognitive skill, and as a soft skill while technical abilities, 'memory, spatial, mathematical and mechanical skills', are classified as cognitive (Charlie's Learning Guide 2014 p. 11).

> **Professional (P) and technical (T) development items**
>
> You will label passages in your internship report with tags – P (for professional items) and T (for technical items) – in the right margins of your internship report (see example to the right of this paragraph). Most of these tags will appear in several passages in your report, depending on the requirements below. They don't necessarily need to be contiguous.
>
> When you describe and reflect on the development of non-cognitive skills during your internship, identify the passages as P items, while activities where you demonstrate the development of and application of cognitive skills should be identified as T items.
>
> As you may also discuss both professional and technical items in the same passages, you will mark them with both P and T tags (or labels). It is important, though, that you address the required word count requirements for the demonstration of the instances and that combining the labels does not waive these requirements.
>
> **N.B.**: In one particular item, (T2), described in section 4.5.3 below, the demonstration of the technical items that refer to the competencies described in the Engineers Australia – Engineering Competency Standards Stage 2 (2012), should be tagged differently in your report.
> Passages that are not properly tagged will not be considered for assessing, grading and marking as the instructors will not make assumptions about their contents – you must indicate the contents of the passages.

Figure 6.1: Extract from Charlie's Learning Guide (2014, pp. 11-12)

The task instructions for students (and this is just an extract) stand in contrast to those found in Bernice's and Harry's sites of practice, where the information given to the students is concise, to the point, and above all easy to follow. It is apparent that Charlie is attempting to remove uncertainty by going into great detail about how to approach the task, although it may have had the opposite effect. Charlie was one of the participants who consented to being observed while teaching. I observed a peer review session late in the semester, when students were required to work in groups to review and give feedback on one another's reflective reports prior to submission.

Students were provided with detailed checklists and written instructions as well as verbal instructions given by Charlie at the beginning of the class. The following is an extract from the observation notes:

> I was struck by how uncomfortable the students seemed to be with peer reviewing one another's writing. The groups that I observed appeared to be uncertain about the procedure, despite Charlie's explanation at the start of the class; when they began the peer review process, they approached the 'low-hanging fruit' of the checklist such as sections which were present or absent, whether there was a table of contents, and whether the students had tagged the sections, but there was no critique that I saw of the actual content of the report. (Observation of Charlie's session, 14.10.14)

The minutiae of the steps required to complete the task, and to complete the checklists prior to submission are complicated to the point of incomprehensibility, so it is not surprising that the students struggled with the peer review process. There are four checklists: two for preparing to write parts A and B of the report, and two for preparing to submit parts A and B of the report. Part A of the report is the preliminary or draft report (I think): 'So previously I used to call parts A and B draft submissions, which was a major mistake, because a draft is something you write on the bus, on the way to [University A]' (Charlie interview). These are supplemented by the report preparation quick guide, which is a three-page condensed version of the 42-page learning guide, which expands on the 13-page subject outline. From this it can be seen how hard Charlie has worked to give students all the information they need to complete the reflective report, and yet the explanations collapse under the weight of detail provided. Thus it is not sufficient to give students an opportunity to practise writing; an understanding of pedagogical and writing practices is needed to make the practices work.

Several of the practice architectures listed in Table 6.1 can also be seen in the analysis of the otherness of writing practices in the engineering curriculum (Chapter 4) and unsupported writing practices in the case studies (Chapter 5). It is perhaps impossible for this study to determine the chain of causation of the practice architectures; the answer may lie in the practice traditions of the engineering curriculum. Practice traditions ‘encapsulate the history of the happenings of the practice, [and] allow it to be reproduced…’ (Kemmis et al. 2014, p. 27). As Nicolini explains: ‘When participants engage in activities in the pursuit of projects, they do the things and speak the language that are characteristic of the practice and enter relationships building on the ‘memory’ provided by the practice tradition’ (2017, p. 104). The prevalence of the practices and practice architectures listed above suggests a strong practice tradition in the engineering curriculum that continually resists the visibility of writing as a developmental practice within engineering studies. I noted in Chapter 1 of this thesis that it is beyond the scope of this research to determine why writing practices are invisible in the engineering curriculum, so the root causes of this practice tradition are open to speculation but perhaps unknowable.

The next section of this chapter provides a glimpse of the institutional practices which sit above the sites of practice and which may or may not support writing practices in the curriculum.

6.2 Faculty support for developing writing practices

Previous chapters have examined the practices in the case studies to see where and how writing practices are constrained or enabled in the sites of practice. The following section of this chapter considers the available evidence regarding the visible support for writing practices at a faculty level: what practice architectures can be detected that support or starve the development of writing practices within the curriculum beyond the individual sites of practice, and beyond the agency of the participant. The original research questions focused on the practices of individual engineering educators, rather than on the institutional practices of their faculties or schools. However, participants were asked about how they saw writing practices being developed from one subject to the next, whose responsibility it was to develop writing practices, and the extent to which their views reflected the faculty view. The participants were asked whether students should be able to develop their writing practices, and a follow-up question (if necessary) asked whose responsibility this was.

There was a range of responses to the question about responsibility for developing students' writing practices, as follows: everyone in the teaching team; all academics; staff and students; no one person; the school; the faculty; course design; a system: 'We developed a system for quality control and learning management' (Ivan interview). It was generally seen as a shared responsibility, and not up to one person.

Quite a different picture emerges from the participants' comments in response to the interview question: 'do your views reflect the faculty view of writing practices?', summarised in Table 6.3.

Table 6.3: Faculty views of writing practices

Participant	Uni	Participant's comments
Adam	A	I think the desire of Jack* [the associate dean teaching and learning (ADTL)] is to improve the writing skills of our students…I support that…other faculty in the higher hierarchy aren't concerned that way because if they were, we would be employing academics who can speak and write English
Bernice	A	in published documents there is probably an alignment…but the faculty view as practised…It's more '…I'm responsible for the content knowledge development in my subject and not for all these other global skills'
Charlie	A	I don't know…It is probably up to me to take the quality on the subject wherever I want… the faculty says we need to have the graduate attributes…I don't think they are being implemented properly…
Eric	A	I think most of the staff have the same…I think for the researcher, supervision, we want to get a student very good in writing.
Damien	B	I can't talk about the faculty at all. I can only talk at the school level… No. I think it just comes down to individuals.
Felicity	C	Yeah, definitely. We usually have regular meetings. We discuss all those issues in that meeting – how to improve…[Felicity is referring to School meetings, rather than Faculty meetings]
Garth	C	In some ways. I think this issue was not really seriously discussed within the faculty...engineering writing, we've not really seriously discussed.
Harry	D	No idea…I don't care… other courses don't do the lab report writing the way we do…Maybe it's not applicable in those lab activities that students write reports in the way that we ask them to do…
Ivan	E	No…up until 2009…I would've said…yes. I think since then there has been a much greater focus on ranking and research and so the whole teaching and learning issues are very much low key…

Note: *Pseudonym

When the responses to the two questions are compared, the most distinctive finding is the apparent absence of visible faculty support for the development of writing practices within or beyond the participants' sites of practice, and the extent to which the responsibility is devolved onto the individual engineering educator. Although the case studies are in engineering faculties in five different institutions, there are commonalities: most participants do not think their views are shared, or they do not know what the faculty view is (or in Harry's case, they neither know nor care), and/or they see it as up to individual engineering educators to decide *whether* or how to develop students' writing practices in their subjects. Damien, whose site of practice has the most strongly integrated writing practices which extend throughout the whole of the integrated engineering program, still believes that the responsibility comes down to individuals. Harry's comment is interesting; he and his disciplinary colleagues have a strongly developmental approach to students' writing practices, but he does not necessarily regard that as a model for other courses. Ivan reports that when he was ADTL of his faculty (until 2009) there was more support for the development of writing practices. Adam, Bernice, Charlie and Eric are from the same faculty but from different schools: Adam notes that the ADTL at University A sees writing as a priority, but other members of the faculty hierarchy do not. Bernice thinks there is a gap between the 'published documents' about the development of communication as a graduate attribute at the faculty level and how that development is enacted or not by individual engineering educators. These views match up with Charlie's comments about the graduate attributes not 'being implemented properly'. Eric assumes that most research supervisors would like to have students with good writing practices. Of the case studies, only Felicity (the most recently appointed engineering educator, who cannot see the writing practices in her own subject) is definite about a shared faculty view of the development of writing practices. However, the meetings she refers to in her comments are school meetings. Her view is not shared by Garth, who is from the same faculty but in a different school: Garth says it has not been seriously discussed, and might be implying that he and his colleagues do not take writing practices seriously.

Overall, the picture that emerges is one of fragmented, unknown, hidden writing practices, located in one subject and developed by individual engineering educators. If there is any faculty support, it is not visible to the participants, nor is there evidence that the faculty takes a developmental approach to writing practices (or to the other graduate attributes located outside of the body of knowledge of engineering). However, it is not only writing practices that are fragmented: as is implied in several case studies, there is little shared awareness of what is being taught or how it is taught in other subjects. The teaching of engineering subjects is atomised, so that shared practices appear to occur only when and if there are strong links between subjects and between colleagues. Garth's and Adam's subjects are isolated within the discipline – both are in civil engineering, and both are the only subjects that cover Transport and Hydrology respectively. Ivan comments that there used to be stronger connections between teaching staff and the development of writing practices (when he was ADTL) than there are now; Bernice refers to the engineering communication subject which precedes hers, but not to subjects that follow. In contrast, Harry's discipline stream (DEC 1, 2 and 3) is an example where the subjects are very sequential; the collegiality among the teaching team is quite strong, as is the development of students' report writing practices. As discussed in Chapter 5, Section 5.4, Damien's case study reveals a quite cohesive program of study held in place by particular practice architectures such as a common curriculum amongst four universities, showing that it is possible within a school to have a coherent set of developmental teaching and learning practices. The siloing of engineering schools or disciplines appears to militate against such practices existing across disciplinary boundaries.

Ivan's mention of 'a system for quality control and learning management' that was developed while he was ADTL of his faculty, and for which he won a vice chancellor's award – 'I have a vice chancellor's certificate for – oh, have I put it away? It's fallen down…' (Ivan interview) is an example of faculty requirements that can be put in place, but which need ongoing support. The system was designed to ensure constructive alignment of learning objectives and assessment within subjects and across programs, including the development of writing practices. It is perhaps an illustration of how all the practice architectures need to work together to hold a practice in place. In this case, the system was implemented some years ago but has not been supported by the cultural-discursive, material-economic and social-political arrangements within the faculty – supplanted by the 'much greater focus on ranking and research' (Ivan interview) so that teaching and learning practices, of which writing practices are a part, are seen as less important. As Ivan points out, there is no guarantee that the levels of writing will be developmental:

…each level's meant to be higher attainment. But in reality they kind of level one, level one, they do my course [subject] as level four and then the next one's back to level two. It's sort of, it's difficult to get that bit right and how to do it right. We've never really discussed – I mean I think I'm asking in a way a bit too much but then if no-one else asks then I can't really stop asking, I think. (Ivan interview)

From Ivan's comments one gets a sense of the effort that it takes to 'get that bit right', and of how easily it could slip into disuse – it is not a practice that can be expected to stay in place without someone watching out for it – which seems to be what has happened since Ivan ceased to be ADTL. In addition there is the conflict that he feels about writing practices; he feels compelled to keep asking that the writing practices are being developed – if he doesn't, perhaps no one else will – but by doing this he is 'asking in a way a bit too much'. His comments show that the development of writing practices throughout an engineering curriculum is no simple task, and that faculty support can neither be assumed nor expected to be ongoing without vigilance.

As pointed out in Chapter 2 of this thesis, the level at which students are required to write throughout their engineering degrees does not necessarily increase in complexity until fourth year, nor does there appear to be shared knowledge of the levels of the writing tasks from subject to subject. Thus while certain practice architectures can enable the developmental nature of writing practices to become visible, they are not currently present at a faculty level at the institutions in which the case studies are located, with the exception of University E: writing practices are visible at University B (Damien's university) at a school level, but not beyond. The implications of this are as follows. If writing practices are to be supported and developed beyond individual engineering subjects, engineering faculties need to have practice architectures which enable this to happen. This would require cultural-discursive arrangements of policy documents that specifically refer to developmental stages of writing (and other communication) practices; material-economic arrangements that provide resources such as exemplars of levels of writing throughout the degree, and social-political arrangements that distribute responsibility for developing writing practices across an engineering program of study. The consequences of not having these practice architectures in place are discussed in Section 6.4. In the next section, 6.3, the invisible writing practices of engineering educators are discussed.

6.3 Engineering educators' invisible writing practices

As part of the investigation of perceptions of writing practices in engineering studies, participants were asked about their own writing practices in engineering. Table 4.1 (reproduced from Chapter 4) lists the reported engineering writing practices of the participants as practising engineers and/or as engineering researchers and educators. All participants except for Eric have had some years of industry experience, and all participants except for Charlie have research publications. Adam and Ivan have particularly strong publications records, each with over 50 journal articles, books and book chapters.

Table 4.1: (reproduced from Chapter 4) Types of writing practices reported by the participants in this study

Participant	Text types
Adam	One-pagers; a nine-book compendium of documents on design flood estimation; emails; reports; ministerials; technical papers; research articles; conference papers; presentations
Bernice	Project documents: (scoping, conceptual design, recommendations, conceptual report, sketches with notes, site instructions); evaluative reports for clients, tenders, presentation notes, lecture notes, research articles; conference papers
Charlie	reports for project management: – financial reporting – preparation of courses in software engineering – scope definition or high level business plans, systems definitions; professional writing courses [while employed by American Express]; writing the learning guides; writing instructions [to students]. Assignments for Grad Cert in HE (including reflective writing); emails to students
Damien	Research reports; reports for managers; newsletters when leading a project team; research articles; technical papers; conference papers; report writing guide for students
Eric	Research articles; conference papers; chapters in books; grant applications
Felicity	Thesis; thesis reports; conference papers; research articles; literature reviews; technical documents
Garth	Thesis; research articles; project reports; team project reports
Harry	Research articles; conference papers; theses; notes; assignments (for Grad Cert in HE); drawings; emails; telexes; writing in a log book
Ivan	Consulting reports; lab reports; journal articles; chapters in books; conference papers

The participants were asked how they developed their writing practices. Table 6.4 provides a snapshot of the different ways in which these practices were developed, and shows that there are few practices in common, except for learning through their PhD. One noticeable point in the interviews was the frequency with which participants initially claimed to have developed writing practices 'by doing them', but then acknowledged the role of a mentor – often their PhD supervisor – after the interviewer asked a clarifying question. Of the nine participants, only Damien immediately said:

> *Basically what with – our students are doing now. So we were required – when I was an undergraduate – to write reports. We were given books and I think I've still got books from the 1970s on writing reports.* (Damien interview)

Table 6.4: How participants developed their writing practices

How develop writing practices	Adam	Bernice	Charlie	Damien	Eric	Felicity	Garth	Harry	Ivan
UG studies		*	*	*					
PhD writing or supervisor	*			*	*	*	*	*	
Formal courses	*		*						
Work examples	*	*		*			*	*	
Work colleagues	*	*					*		
Journals or templates					*	*	*	*	
Uni colleague		*		*	*				
Other	School subjects; mother		mother; books	books				HS English teacher	Flat–mate

All the other participants saw themselves as having learned by doing, until they were asked if there was any other input, at which time they usually acknowledged either feedback and mentoring or being shown examples of reports at work. The overall impression is of engineering educators seeing themselves – initially – as self-taught practitioners of engineering writing, and of *not immediately seeing* the mentoring and modelling practices of learning to write in particular sites of practice. For eight of the nine participants, the development of their own writing practices is, if not invisible, somewhat less than apparent. When this line of reasoning is followed through the case studies, it can be seen how the practice architectures in the engineering curriculum interact to render writing practices invisible through pedagogical practices, through faculty practices and through some kind of knowledge blindness. This type of knowledge blindness is explained by Maton (2014b) as a perspective which assumes that all knowledge is homogeneous, and thus the language used to communicate this knowledge is also homogenous, or generic. As discussed in earlier chapters (e.g. Chapter 1, Section 1.2.1), writing in higher education, and in engineering studies, is frequently regarded as an everyday kind of knowledge; academic educators are often blind to the writing practices they have developed through their disciplinary studies. In the case of the participants in this study, even when they have learned engineering writing practices through mentoring, feedback and modelling, if they do not recognise this is how they learned, they are unlikely to practise this with their own students.

Again this understanding takes us back to the idea that for most participants in this study and engineering educators in general (as can be seen from previous studies of engineers and writing as covered in chapter 2), writing is not recognised as a developmental practice. The case study of Damien may be the exception that proves the rule: he learned to develop his engineering writing practices at university with explicit instruction, 'we were given books', and through being mentored by his PhD supervisor: 'It's sitting down with my supervisor, side by side, him getting his pencil out, he is the one who taught me how to write' (Damien interview). This is what he practises with his students from the beginning of their engineering studies: explicit instruction, feedback, red pen ('I'm probably notorious in the school for the use of red pen. So I spend perhaps too much time on writing comments on the report itself'), and providing exemplar reports. The practice tradition of his learning formed the practice architectures of his teaching practices, and perhaps this is a necessary but not sufficient condition for engineering educators to see writing as a practice, and one that they can assist their students to develop.

The consequences of the invisibility of engineering educators' own writing practices on how they develop their students' writing practices are discussed in the next section, which looks at what happens when writing practices become visible in the engineering curriculum – in the final year of the degree program – which I have referred to as 'the miracle of fourth year'.

6.4 The visibility of writing in the engineering curriculum

6.4.1 The miracle of fourth year

Possibly the most cogent illustration of the problem of the invisibility of writing practices is what happens in fourth year, which is the final year of study for engineering students in Australian universities. This is when students are expected to write (produce) an extensive research document, either an honours thesis or capstone project report and thus when writing practices become very visible. There is a significant shift in expectations from both engineering educators of fourth year students, and from the fourth year students themselves about the importance of writing, at least in part because the major assessment task is a written artefact of some kind. In fourth year, students take their writing seriously, as do their teachers; fourth year is magical: students are transformed – into novice engineers, or novice researchers. The visibility of the writing practices has several manifestations: firstly it is the artefact of the final year thesis or project; it is also that final year students are seen as researchers, so they are shown their teachers' own research writing. Additionally, and not surprisingly given the lack of practice that many students have with research writing, students' writing practices become visible in their lack of adequacy for the task. The importance accorded to fourth year in terms of students' writing practices by the participants in this study emerged through the data analysis, notably the frequency with which the fourth year or final year is mentioned (38 times). For several of the participants, this is when, and only when, they can see their students' writing practices as being part of their engineering studies. For example, in the cases studies of Garth and Felicity the writing practices of fourth year students can be commented on, whereas students in lower years still have invisible writing practices.

Thus fourth year is viewed as the time when the students 'get serious'; this seems to be prefigured by the practice architectures in engineering faculties – one of those possibly untraceable assumptions around engineering, but which is repeated by Garth and Ivan in this study.

> *But, I think in their fourth year their writing skills actually improve somehow... Well, some students take the fourth year project more seriously than the third year. That's why it's better; their practices improve their writing skill.* (Garth interview)

Garth's comments are echoed by Ivan:

> *So I think by the final year they've got it…Yeah, no somewhere along the way – I mean so I don't know quite whether it's because they're not taking it seriously and they were capable of doing it.* (Ivan interview)

Garth and Ivan are from two different institutions but both share the perception that 'somehow' students in fourth year begin to take writing seriously and thus their writing practices improve. Their comments suggest that it is the students' agency that has brought about this change, rather than a combination of a change in expectations from the engineering educators and the realisation that a significant proportion of students' final marks will depend on writing a very large text. It brings to mind an explanation provided by Winsor (1996), who refers to Geisler's (1994) claims that college students have problems seeing written texts as anything other than presentations of facts:

> Only advanced students who are on the verge of joining professions are allowed an insider's glimpse of how and why texts are rhetorically constructed. Students' achievement of a rhetorical view of writing is one of the signs they are about to become knowledge generators in their fields rather than passive

recipients of given wisdom that cannot be challenged. (Geisler, cited in Winsor 1996, p. 7)

Thus in fourth year engineering writing becomes visible because students are moving from the periphery and closer to the centre of the community of practice (Lave & Wenger 1991), and are expected to start generating knowledge in their research projects; they are taken seriously by their lecturers. Students below fourth year are not expected to take writing seriously – they are at the very outer edge of the community of practice. In fact, three participants in this study specifically say they do not show their research writing to students below fourth year (Felicity, Garth and Ivan), but share their writing with students who are fourth year and above (research students).

Yet as previously noted, there is very little visible preparation for or development of the writing practices required in fourth year, which are substantially different from other writing students may have done in earlier years, and much more extensive. The honours thesis or capstone report is a substantial text which is expected to demonstrate the student's research skills, including a command of research literature.

Writing practices therefore become visible through the production of an artefact (thesis or report), and visible in the sense that Turner (1999) uses, where writing becomes visible when it is problematic. Several participants observe that not all students are competent writers by fourth year, and interestingly it is the participants whose practices provide the most support who seem to have the strongest awareness of problematic writing:

- *Although I still see examples where students are in fourth year -…I find that some of that is still pretty hit-and-miss.* (Harry)
- *It takes a lot of feedback – and feedback's important for students – for the students to understand their weaknesses and where they can improve in the future… So even fourth year students are still struggling writing reports.* (Damien)

- *For most students that come in in their final stages for capstone supervision that I see, their writing has developed compared to most first years that I see. That's most, not all.* (Bernice)

Even more interestingly, the participants who believe most strongly in the miracle of fourth year are those whose practices do not provide formative feedback or scaffolded assignments.

Garth acknowledges quite clearly the gap between what students are required to do in the fourth year report and the lack of support or guidance provided to them by engineering academics:

> *The fourth year project, that's what we exactly want from our student. This is reviewing the current design of a transit system and prepare a professional report, evaluation report of the current design. So we hope that particular project work can help the student's writing skills. But we don't do anything to help them. We give a task; we don't really help or advise how to help achieve that. (Garth interview).*

It is a revealing admission: it shows that Garth can see what is missing, and is probably in a position to assist at least some of the 4th year students, but recognises that he and his colleagues do not provide systematic support. He may also recognise that the support he provides is ad hoc and one-to-one rather than support for the whole cohort.

Damien comments on the lack of developmental writing practices in other schools in his faculty; he is a member of a taskforce endeavouring to ensure uniform standards in thesis courses across the engineering schools in University B.

> *…there are different approaches based on the feedback or comments which are made by the different committee members. Some are quite – not shocking so much but surprising in terms of you're doing – you're requiring that of your students now in fourth year? It wasn't required earlier?* (Damien, interview)

Damien is 'surprised' that other schools do not develop writing practices the way that his school does; based on this study and on anecdotal evidence, the practices in his school are the exception rather than the rule. And yet he should be surprised, as should all engineering educators, that final year students are expected to know how to write an extended research report with scant previous experience in writing anything longer than a lab report. It is a mystery as to where the students will acquire this knowledge, if it is not made explicit, not practised, and not emphasised before this time. Either it is assumed that this will happen because students will adopt a more 'serious' attitude (Garth and Ivan) or that they will learn by doing the project, as Felicity says:

> *RG: How do your students learn or acquire those engineering writing practices?*
>
> *Felicity: I think there is a – for final year project they will learn how to do so…*
>
> *RG: Do you show your students your...*
>
> *Felicity: Definitely. For instance I had a student for the final year project last year – they do not have an idea about how to design the report. I try to help them – and also I had several journal papers – conference papers.* (Felicity interview)

This short extract encapsulates several practices. It shows practices where engineering educators think students will learn how to write a report by writing a report (Adam's practices also show this), at the same time as recognising that some students do not know how to write a report. It shows practices of providing individual guidance to specific students *in fourth year* who will learn by being shown the engineering educators' research writing; Garth has similar practices with his fourth year students, showing them his research writing and providing feedback on their projects throughout the semester, on an ad hoc basis. Felicity, Garth and Ivan do this only for fourth year students. The cultural-discursive arrangements of Felicity's and Garth's sites of practice prevent writing from being seen as a practice – it is perhaps a skill that is learned just-in-time for a particular task, such as a capstone project report, rather than a kind of knowledge that is developed through and with the learning of the propositional knowledge needed to become an engineer. The participants' practices reflect the practice traditions of how they themselves developed their engineering writing practices – through being shown exemplars, such as conference and journal papers, and through one-on-one advice from supervisors or colleagues. However, the invisibility of how they developed their writing practices forms the practice architectures of their sites of practice and constrains them from seeing writing as a developmental practice within the engineering curriculum. What is invisible to engineering educators is also invisible to their students. This would explain why the guidance about research writing provided to their students is not systematised or embedded in their subjects; it is not seen as knowledge but as individualised advice. Writing only becomes visible when the stakes are sufficiently high, and it is time – for the students and for the engineering educators – to 'take it seriously'.

6.4.2 Visible writing as a practice in the engineering curriculum

The practice architectures of the case studies where writing as a practice is visible and supported beyond the local site, and can thus be seen as part of the 'project' of the site, are formed by a complex interaction of pedagogical practices, collegial practices, and agency of the participants.

The pedagogical practices include**:** participants talking about writing practices as being key to learning; their students enacting writing practices in class time or for assignments (doings); providing formative feedback to their students (doings) and demonstrating knowledge of writing practices in subjects taught by their colleagues (relatings). The collegial practices of the participants involve working with engineering colleagues to extend the writing practices beyond their sites, and allowing the practice of writing to be seen as developmental. Some participants also collaborate with ALL lecturers. All of the institutions in which the case studies are located have ALL lecturers who work with academic staff and with students to develop academic literacies either across the curriculum or within disciplines. Of the nine participants, three make specific mention of working with the ALL lecturers in their respective universities: Damien (University B), Harry (University D), and Ivan (University E). Practices shape and are shaped by their spatial and temporal locations, so each of these collaborations is unique to its site of practice. Damien's collaborations with the ALL lecturer are ongoing; she is co-author on the RWG and gives guest lectures on specific aspects of writing. Harry has called on the ALL team to give lectures on report writing, and refers students to the ALL unit:

…we say okay go see the ALL unit, take along a sample of your writing and ask them to critique it. Get the feedback and work with them, they're the experts. Come to us and we're the experts on the circuit theory. (Harry interview)

Harry's sayings highlight his collegiality with his engineering colleagues (he almost always refers to 'we' – his teaching colleagues) and with the ALL unit; they also show that he recognises different areas of expertise, and that writing is an area of expertise. He is the only participant to acknowledge this specifically, although Damien's collaborative work with the ALL lecturer at his university strongly implies that he recognises her expertise. Ivan has worked with the ALL unit at his institution and directs his students to access the online writing resources available on the open access WRiSE and iWRITE sites (University of Sydney 2012). However, he says in the following extract when discussing the online and face-to-face literature review workshops provided by the ALL lecturers:

Yes. I mean I don't think they do it very effectively, yeah. I think what I did was much better of course [laughs] but, yeah, because the students still come and ask me how do you write a literature review and, yes. (Ivan interview)

When he says 'I think what I did was much better of course', he is referring to an earlier discussion in the interview about a subject he had previously taught which focused on students learning to write a literature review. Ivan's comments could be interpreted in different ways. It could be that the ALL workshops on literature reviews are not as effective as the subject he taught**,** or that the ALL lecturer was teaching students how to write literature reviews in general, whereas Ivan would have been giving very specific advice about how to write a literature review for a particular assignment. Another interpretation is that Ivan's sayings reveal cultural-discursive arrangements where writing is not thought of as an area of expertise; it is 'common sense' knowledge and does not require specialist understanding. It can therefore be taught by anyone.

The third major component of the practice architectures in making writing practices visible is the degree of agency of the participants as part of 'the ways that practices develop and are held in place both in terms of the agency and actions of individual' (Kemmis et al. 2014, p. 15). While several participants exercise agency to make writing practices visible within their sites of practice, only Damien and Harry have sufficient agency *combined with* the practice architectures of pedagogical practices and collegial practices to make writing practices visible beyond their sites of practice. The practice architectures of Harry's site enable the visible, sequential development of writing practices throughout the disciplinary stream of electrical engineering in his faculty, as can be seen in the following interview comment:

> *…one of the people who did DEC 1 last year did DEC 2 this year which must have been fun for the students because sometimes they say, oh we've never seen that before and he can say, yes you did, I was there.* (Harry interview)

The comment demonstrates the collegiality and the importance of sayings that demonstrate to students the links between engineering subjects and writing practices. Damien's agency is considerable, as his practices have embedded report writing as a visible, developmental practice throughout the curriculum in the school of integrated engineering from first to fourth year, and possibly beyond into the curricula of the three other participating universities in integrated engineering in Australia. Neither Harry nor Damien mentions resistance from their colleagues in developing writing practices; perhaps the practices are so enmeshed with the content that they have become - not so much invisible, but seamless.

Yet despite their apparent success in developing students' writing practices, there is no evidence that what happens in Damien's school or in Harry's disciplinary stream is regarded by either of their faculties as a model of good practice, or as practices to be emulated. One likely explanation is that the practice architectures in a number of engineering faculties facilitate a silo mentality; good practices – of teaching, learning, and subject design – may exist in one school but may be unknown and therefore invisible in another school. This is exacerbated by the practice of academic ownership of subjects, where subject coordinators focus only on what happens in their subject, and thus may have little interest or knowledge about practices in other subjects.

6.4.3 Implications of the invisibility of writing practices: What happens when the miracle fails to occur?

The implications of the invisibility of writing practices can be seen in fourth year when at least some students struggle with managing the task at hand. In the words of the participants:

- *They do not have an idea about how to design the report.* (Felicity)
- *But I find, like for example, a very top student sometimes the writing is not good.* (Eric)
- *Everyone agreed they were dreadful. Had no idea about how to present the information.* (Ivan)

Yet these perceptions of the problem of poor writing practices do not recognise or acknowledge the practice architectures of the curriculum which have constrained the development of writing practices in the earlier years because of the focus on transmitting propositional knowledge:

> When [science and technology] students write for their subject teachers who are already fully informed of the subject matter, there is no need to be persuasive or argumentative: masses of data can be regurgitated, often in a rambling and disorganized fashion. Subject teachers may only check for content…. (Braine 1989, p. 13)

This approach, often known as 'the information dump', is familiar to many engineering academics, and the cause of some dismay. However, when assessment criteria emphasise reproduction of technical knowledge and minimise the need for persuasion or argument, it is understandable that many students will adopt the information dump approach, and will probably not lose marks for doing so. Thus the leap from these practices in the first three years to what is expected of students in fourth year is often sudden, large and unexpected.

Of perhaps greater concern is that when students write a thesis or capstone report, they may not see this writing as part of their engineering practice, as the emphasis will have been on producing an artefact, rather than: '…to be able to explain clearly what they're doing and why they're doing it' (Ivan interview, commenting on the role of the thesis). 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, to transfer knowledge learned in one subject to different contexts, or to write for different audiences. One outcome of this absence of practice is engineering graduates who may lack the integrated knowledge required for engineering practice, and who may have limited communication capabilities. This thesis argues that being able to see writing as a practice, and a practice that has been developed throughout one's degree, enables engineering graduates to continue the practice of writing, no matter what the context. 'Knowing how to go on', or knowing the practices of engineering writing, is seen by Bernice, Damien and Harry as ways for graduates to develop professional identity, develop their critical evaluations, and improve their chances for success in industry.

6.5 Conclusion

This chapter has argued that the prevailing practices of othering writing practices and of unsupported writing practices interact to form practice architectures that render writing practices invisible in the engineering curriculum. This can be detected in the practices of the participants in their sites of practice, in faculty practices that do not make writing practices visible, and in the invisibility of the participants' development of their own writing practices. The practices of the curriculum do not speak of, enact or value writing practices as part of what engineering does. Many participants have only a partial understanding of writing practices; furthermore, the practice of modelling writing practices for their students is not common. Several participants only show their research writing to their research students (fourth year and above); somehow, the writing that students do from first year to third year is not visible. Writing practices become visible in the curriculum only when high stakes assessment tasks requiring extended writing compel students and staff to take writing seriously, and that is usually not until fourth year. When writing practices obtrude upon the attention of engineering educators, they provide guidance and feedback to individual students, showing them their own research writing and directing them to appropriate journal articles. Most if not all of the participants have an expectation of the type of writing that the students should be producing, and can produce this writing themselves, but are not comfortable about giving input about how the students should approach or acquire the expected style and genre. Specifications such as ‘professional style’ or ‘an engineering report’ do not generally provide sufficient illumination of the standards expected.

The practices of the majority of the participants in this study suggest that for them, writing is not a practice; it is a set of skills that perhaps only need to be taught once and can then be transferred to different contexts. While writing is viewed as other by some participants, it is also regarded as common sense knowledge which does not need particular expertise to acquire. The invisibility of the development of most participants’ own writing practices appears to reinforce this view.

However, this chapter has also shown that writing practices can be made visible throughout the curriculum as an integral part of studying engineering. The social-political arrangements of engineering educators valuing writing practices and of working collegially with other engineering educators in related subjects, the material-economic arrangements of integrating the writing practices as part of learning the propositional knowledge, and the cultural-discursive arrangements of including explicit instructions about writing practices in subject documents interact to support writing practices, and to make them visible so that they can be seen to be developed. These practices are held in place by the interrelation of practice architectures and by the agency of the participants. The necessary pre-conditions appear to include collegial practices, strong links in propositional knowledge between subjects and subject coordinators who value writing practices. Harry’s case study demonstrates this, but there is no guarantee that writing practices will remain visible in the DEC stream when Harry and his colleagues leave the institution. Damien’s case study suggests that the unique practice architectures of his site of practice can hold writing practices in place as part of the engineering curriculum, possibly even after he leaves the school.

Writing practices are invisible in the engineering curriculum, but they do not need to be. Nevertheless, the effort required to make them visible, developmental and seen as a shared responsibility amongst engineering educators seems far greater than maintaining the status quo, despite the perceived benefits of strong writing practices. Ivan says:

> *…I think one of the main benefits of writing a thesis is presenting a coherent message over a thick book, is one of the most valuable bits of the thesis. Yeah, anyway so it's because I value that; and I think it's because I'm an experimentalist as well. So it's all about interpretation and your ability to understand what's going on. It's not about the mathematics. For me, anyway. That's my interest, yeah. I think that's actually why I'm more interested in this because it is actually more critical to people who do experimental work. To be able to explain clearly what they're doing and why they're doing it. Whereas if you're doing maths you just say well here's the theory and then I'll do the maths later and here's the result so this is what it means.* (Ivan interview)

Ivan's comment exemplifies the contradictions that exist in his own practices and more widely in the engineering curriculum. Writing practices can be very powerful, as a means of interpreting and understanding complex information, and as a means of communicating that understanding to other people. However, the practice architectures of the engineering curriculum tend to set up a polarity whereby either engineering science knowledge or writing practices can be developed, but not both, and certainly not in the same subject. Alternatively, and sometimes simultaneously, writing practices are positioned as other, and therefore as outside the domain of engineering knowledge.

The following chapter (Chapter 7) concludes the thesis by summarising and synthesising the arguments that have been made in Chapters 4, 5 and 6, and considers future directions for research.

Chapter 7
Conclusion

Speaking of the invisibility of writing practices in the engineering curriculum

7.1 Review of study aims and questions

I have had extensive experience working with engineering educators in the realm of engineering education, including being the first author or co-author on several journal articles and conference papers. I have worked with writing experts in the field of engineering communication to design and teach engineering communication subjects; I have given lectures to engineering students on written and spoken communication in their disciplines. I have designed online and in-class resources to develop engineering students' written and spoken communication practices. A puzzling element of my experiences and those of my colleagues was why a few engineering educators sought to support their students' writing practices, through their own efforts and by calling on the services of writing experts in their universities, while the majority of engineering educators did not engage with this at all. In all of these experiences, my understanding of writing in engineering studies came from my and others' work supporting students' writing, and from published research which focused mainly on interventions to help students write. The perspectives of engineering educators about writing practices were largely missing. There was little research on how engineering educators saw writing practices within the curriculum, nor about how writing might be practised across a number of engineering subjects or throughout a degree program. There was also little information about how writing practices have come to be spoken of as not being part of being an engineer. I did not know how engineering educators spoke of writing practices to their students, nor what opportunities there were for students to practise writing with or without being assessed on written tasks. This study sought to investigate the perspectives and pedagogic practices of engineering educators of writing in the engineering curriculum. From this I hoped to gain a deeper understanding of how writing practices are spoken of, enacted and valued in this environment, in order to inform my own practices as an ALL lecturer and to inform the practices of engineering educators, and to contribute to the research on writing in engineering.

After establishing that this area was under-researched, I considered how best to frame the research questions. I decided to use the metaphor of the invisibility of writing practices in the engineering curriculum, as it allowed me to consider the extent to which writing practices were undetected, undetectable, missing or absent. With this metaphor in mind, I developed the following research questions:

- How are writing practices invisible in the Australian engineering curriculum?
- What are the contributing factors that make them invisible?
- What are engineering educators' perspectives of writing practices in the engineering curriculum?
- What constrains and enables the development of writing practices as part of learning to become an engineer?

The study was designed to give a rich picture of engineering educators' perspectives of writing practices in the context of the engineering subjects they taught, from interviews, document analysis and my observations of some teaching practices. A case study approach combined with a PAT lens enabled an analysis which focused on the practices within each case study and across case studies. The analysis provided understanding of the local conditions of practices and how they could be seen as part of the practice landscape of the Australian engineering curriculum.

7.2 Summary of key findings

The following section highlights the key findings in relation to the research questions. I then consider some implications of the research findings, especially in the context of using PAT as a way of analysing issues in engineering education. I discuss some limitations of the research findings and of the methodology, before raising future directions for research into writing in the engineering curriculum and in engineering practice.

7.2.1 How are writing practices invisible in the Australian engineering curriculum?

Writing practices are rendered invisible in the engineering curriculum through a complex interplay of practice traditions, prevailing practices and practice architectures which hold certain practices in place and prefigure what is sayable, thinkable, doable and relatable about writing practices in engineering studies.

Chapter four presented a model of an ecology of practices to support writing practices, comprising practices where writing is spoken of and thought of as a practice; where it is practised and given formative feedback; where it is weighted as part of the assessments; where it is seen to be developmental and as forming part of an engineer's professional identity. This chapter argued that the lack of an ecology of practices in the practice landscapes of most Australian engineering faculties is an overarching condition that does not support writing practices, and consequently renders them invisible. Furthermore, the prevailing practices in engineering education constrain the development of writing practices in the engineering curriculum through ecologies of practices which neglect the development of writing practices by directing resources towards acquiring technical knowledge. The majority of the sites of practice in this study lacked ecologies of practices that would allow writing practices to flourish, while others had fragmentary elements of practices. Limited ecologies of practice to support writing practices could be detected in the case studies of Bernice and Harry. Only in Damien's site of practice was there an ecology to support writing practices throughout the degree program of integrated engineering at his university.

Chapter 5 explored the notion that writing practices in the engineering curriculum are not merely marginalised, as they are in the wider university curriculum, they are regarded as other, as strange, as not what belongs in engineering. The otherness of writing practices emerges from the prevailing identity of engineers as masculine, solitary, technical rationalists, and from engineering science being the predominant focus of the engineering curriculum. The findings from the case studies showed that for several participants writing practices are seen to occupy an emotional domain, in contrast to their view of the propositional knowledge of the engineering subjects they teach, emphasising the strangeness of writing practices to engineering studies. Writing is not seen as one of the practices necessary for becoming an engineer; it is instead associated with English language proficiency, literary studies and rules of grammar. It is thus regarded as a skill that students should acquire or be taught elsewhere, and be transferred to engineering contexts when required.

Chapter 6 argued that the prevailing practices of *othering writing practices* and of *unsupported writing practices* interact to form practice architectures that prevent writing practices from being seen as an area of knowledge that is expected to be learned by student engineers. Writing practices are thus rendered mostly invisible in the engineering curriculum at subject, course and institutional levels until the final year of an engineering degree; there is no general expectation from staff or students that writing practices should be developed. When curriculum requirements demand that students must produce an extended piece of writing as part of their research for a thesis or capstone project, writing practices become visible. However, the visibility is often caused by students' inadequate writing practices; considerable effort is then exerted by engineering educators and students to 'fix' the problem in order to produce the artefact of the thesis or the capstone report, , or to somehow overlook the poor quality of the writing by focusing on the 'content'. It is unlikely that this will be adequate to provide students with strong writing practices in their careers as practising or research engineers.

7.2.2 What are contributing factors that make writing practices invisible?

One group of contributing factors that make writing practices invisible in the engineering curriculum, as discussed in Chapter 4, are: cultural discursive arrangements which see writing as a skill; material-economic arrangements that give minimal weighting to writing in assessment tasks, provide few or no opportunities to write discursively and where there is limited feedback or no formative feedback; and social-political arrangements that do not include communication as a learning outcome in subject documents, and where there are no connections with other subjects or colleagues to develop writing practices. At an institutional level, these arrangements could include the tendency of engineering faculties to hire research engineers (often from an engineering science background) with little or no prior industry experience to teach engineering. They interact with engineering educators' practices to conceal the role that writing practices can play in learning to become an engineer. These arrangements and the practices that are prefigured by them can be found in most participants' sites of practice, although the influence of the practice architectures may not be recognised by the participants.

A second group of contributing factors are the practice architectures which prefigure the belief that writing is a different kind of knowledge; they interact with other practice architectures to keep writing practices unspoken, and unspoken about, and thus invisible. The evidence of their influence is demonstrated by engineering educators' lack of a meta-language to talk about writing practices, and quite possibly a lack of confidence in their competence in writing, or in identifying the specifics of good and poor writing. This is a consistent problem that emerges throughout the study. If engineering educators are unable to describe clearly to their students what is required in a written assessment task, if they do not have the appropriate terminology to give constructive feedback on students' writing, or to articulate clearly the level associated with learning outcome achievement, and if they struggle to name their own writing practices and how they learned them, the development of students' writing practices will necessarily be constrained.

Another set of contributing factors is an apparent absence of institutional support for the development of writing practices, and the resultant isolation of the engineering educators. Working alone, engineering educators generally cannot develop writing as a practice, as the practice tradition of the curriculum, and the practice landscape of their faculties do not provide the intersubjective spaces for writing practices to flourish unassisted. Without some kind of mediation and interactions with pedagogical practices (Bernice, Damien and Harry), writing is treated as a coding exercise (Charlie's case study, where the protocols and tagging of elements of the reflective reports obscure the reflective writing task), as an artefact (Adam), as ephemeral (Eric, who sees research writing as very important and works with the students to give them feedback about their writing but does not incorporate it into his subject documentation), as outside the boundaries of the subject knowledge (Felicity and Garth) or as the Other (Ivan, whose interview reveals his ambivalence about writing: it is important, but not; easy, but not; crucial, but not; valuable, but not).

There is an assumption, as illustrated in Chapter 6, Table 6.3, that the responsibility for the development of students' writing practices lies with the individual subject coordinator, and not within a supported course, program or faculty structure. In all of the case studies, there was no visible faculty support for the development of writing practices, nor of other professional attributes such as teamwork, within or beyond the subjects taught by the participants. The institutional support in Damien's case study has come about not through his engineering faculty, but through Damien's leadership in his school, and in the national integrated curriculum overseen by the peak body for his discipline. In the other case studies any support was provided by individual participants working by themselves or in collaboration with faculty and university colleagues. The role of the faculty in all of the institutions in the case studies at the time of data collection (as noted by Ivan, things were different a few years ago at his institution) appears to be confined to including communication as a faculty graduate attribute, as commented on by Bernice in Table 6.3:

> *In published documents there is probably an alignment…but the faculty view as practised…It's more '…I'm responsible for the content knowledge development in my subject and not for all these other global skills'.* (Bernice interview)

As discussed in Chapters 4 and 6, while considerable efforts can be and are made to support writing practices in several of the case studies, such efforts cannot guarantee sustained practices beyond the (professional) lives of the individual participants. Consequently, the development of writing practices in Bernice and Harry's sites may cease to exist when they leave their respective sites of practice, unless there is a considerable shift in the practice landscapes of their institutions to support writing practices within the curriculum. In Damien's site of practice there is a greater chance of writing practices surviving because of institutional practice architectures, such as the existence of an Australia-wide curriculum in integrated engineering overseen by a national association of integrated engineering, and the artefact of the RWG which is apparently used in all member institutions of the association of integrated engineering.

7.2.3 What constrains and enables the development of writing practices as part of learning to become an engineer?

> Some practice architectures are more durable than others. Some have the weight of living and consciously-remembered traditions of thought and action justifying them; some stay the same over time merely by habit; some are kept in their course by coercion or ideology; some are kept in place by rules and sanctions, by regulation and compliance mechanisms. (Kemmis 2009, p. 34)

Kemmis's observations about the durability of certain practice architectures provides a way of understanding why the practice architectures that constrain the development of writing practices in the engineering curriculum are so seemingly immutable. It is quite likely a combination of all of the factors identified by Kemmis that keep these arrangements in place in the Australian engineering curriculum: traditional approaches to teaching – many engineering educators teach as they were taught; the habit of not writing in the discipline; ideologies around what does and does not belong in the engineering science curriculum; faculty rules and requirements about individual assessment of knowledge (exams), along with shortened teaching periods but with no reduction in course content (and often pressure to increase this content) to be covered in class. Another element is the situated and socio-cultural nature of writing practices, where the knowledge needed to develop them requires human rather than automated feedback. This contrasts with much of the mathematical knowledge of engineering, which can be practised and checked online or with a textbook. All of these interact and influence the practices found in the sites of practice analysed in my research.

7.2.4 What constrains the development of writing practices as part of learning to become an engineer?

Based on the findings from this study, the following claims can be made.

Prevailing practices in engineering education constrain the development of writing practices in the engineering curriculum when:

- Writing practices are not part of the dominant narrative of engineering education.

- Writing practices are not part of the identity of an engineer.
- Writing practices are seen as a different kind of knowledge and thus as separate from the learning of technical knowledge.
- Writing practices are regarded as competing with the acquisition of technical knowledge.
- Writing practices are unsupported in a subject, a sequence of subjects, or throughout a degree program by not being practised, not being formatively assessed, and not being specified as a learning outcome in a subject or course.
- Writing practices are not seen as developmental throughout an engineering degree; they are instead regarded as context-independent skills.
- Writing is confused with English in the minds of engineering educators; being asked to develop writing practices can thus be conflated with being asked to teach English.
- There is a lack of agency on the part of the engineering educators to support writing practices.

The following paragraphs expand on these claims.

It can be seen in this and in previous research that the overarching narrative of engineering education is a focus on technical knowledge that is hard-won, and which does not leave room for the development of professional qualities such as well-developed writing practices. For some of the participants in this study, the approach to not practising writing is almost visceral; it is not part of what engineering is about. The development of students' writing practices does not appear to 'contribute[s] to the formulation of their [the participants'] identities as people of a particular kind, and their agency and sense of agency' (Kemmis 2009, p. 23). It challenges their identities as engineers. These approaches are manifested differently in each site of practice: for example, the cultural-discursive arrangements of Adam's site do not match his sayings. Charlie's learning guide and instructions for writing a reflective report, designed to remove ambiguity, also reduce reflective writing to a coding exercise. Felicity thinks she is describing the writing practices in her subject but is actually talking about the technical knowledge her students are learning. Garth removed the group project assignments from his subject to focus on all the topics that needed to be covered. Ivan demonstrates a conflicted perspective in his sayings and in the assessment practices of his site. In diverse ways the practices of these participants, like the participants in Leydens' (2008) study, separate the rhetorical development of their students from the development of their technical knowledge, and their writer selves from their engineering selves. The practices which separate writing from technical knowledge interact with teaching and assessment practices so that writing practices are regarded as being in competition with the acquisition of technical knowledge.

The competition for resources in terms of time and money, for teaching time and for time spent on marking students' written work in several of the case studies **c**onstrains the development of writing practices. Competition is a recurring theme in the discourse of engineering, both in the engineering curriculum with its focus on rigorous standards and the weeding-out culture, and in engineering practice, where 'winning', competing, bidding, succeeding and failing are commonly used terms. It is thus not surprising that there should be practices which enable competition for what is taught, and the space and time in which it is taught. As noted in Chapter 4, Shove and colleagues (Shove, Pantzar & Watson 2012) regard practices as competing for space and time with each other; those which are allocated more time and space are (or become) more dominant practices. The relative cost of including writing practices in the teaching and learning practices of their subjects is acknowledged in several case studies: Adam, Bernice, Charlie, Damien, Garth, Harry and Ivan all comment on time spent on marking and/or giving feedback on students' written work. Harry makes a specific reference to the cost of giving feedback in this context, but immediately follows this statement with a comment about how valuable it is:

> *This of course takes time which makes the whole assessing thing an expensive thing. But that's really where the value is in the teaching.* (Harry interview)

Those sites of practice where writing was seen to be in greatest competition with propositional knowledge for the scarce resources of teaching time, student effort and time taken to assess were also those where most or all of the elements of practice were missing – writing practices were on the losing end of the competition. The interactions of these practice architectures and practices meant that in the majority of the sites of practice in this study there was no support for writing practices – there were limited or no opportunities to practise writing within the context of learning the propositional knowledge, there was minimal or no formative feedback for written assessment tasks, and/or the development of written communication was not specified as a learning outcome in a subject or course.

The different understandings of what is meant by 'writing' in engineering impacts teaching and assessment practices. For example, the cultural-discursive arrangements which conflate or confuse writing practices with 'English' can prefigure practices that outsource the development of students' writing practices because engineering educators do not see themselves as teachers of English. Furthermore, the perception that writing is a context-independent skill is part of the practice architectures which keep writing practices separate from propositional engineering knowledge. Writing is thus expected to be acquired elsewhere (in high school, in a communications workshop, as part of a study skills package) – the practices of Adam, Charlie and Felicity suggest this – rather than being a developmental practice that accompanies other practices of learning to become an engineer.

Finally, a perceived lack of agency, or mindful agency (Deakin Crick et al. 2015) on the part of practitioners, interacting with the practice architectures within their practice landscape, constrains the development of writing practices in certain sites of practice. Mindful agency is defined by Deakin Crick and colleagues as 'the self as agent of his or her own learning, able to take responsibility for the process, as well as managing feelings in learning and being able to judge how long something may take and how to go about it' (2015 p.135). Mindful agency is regarded as a key construct in learning dispositions, but could also be applied to teaching dispositions. The combination of mindful agency and Bandura's view of agency: '[U]nless people believe they can produce desired results and forestall detrimental ones by their actions, they have little incentive to act or to persevere in the face of difficulties' (2001 p.11), may partly explain some of the practices in the sites of practice. For example, in Garth's case study it may be that the weight of the prevailing practices of his school and faculty not to 'take writing seriously', combined with a lack of belief that he can make changes himself, and possibly a lack of confidence in his own writing practices, cause him to avoid developing students' writing practices in his subject. In Ivan's case study, the faculty practices of focusing on research rather than on teaching and learning appear to be eroding what he thinks are good writing practices in the curriculum of his institution.

7.2.5 What enables the development of writing practices as part of learning to become an engineer?

The development of writing practices within the engineering curriculum is enabled when:

- Practice architectures of a site of practice interact to support writing practices as part of the learning practices performed by engineering students and staff.
- There is an ecology of practices that supports and nourishes writing practices in the engineering curriculum, through educational leadership, professional learning, educational research and evaluation, teaching practices and learning practices that practise writing in the engineering curriculum. The presence of pedagogical understanding appears to play an important role in this ecology.
- Practice architectures extend beyond a single site of practice to other sites – collegial practices are important – so that writing practices are made visible (are spoken about, practised, valued and linked to other tasks), and are regarded as developmental practices throughout the engineering degree.
- An engineering identity includes a 'writer self'.
- The subject coordinators have a sense of agency.

The following paragraphs explore these summary points in more depth.

All elements of a practice are equally relevant, but it seems to be the relationality of writing practices that is key to its survival and continuance as a practice. Writing practices in the engineering curriculum need the appropriate people, policies, artefacts and organisational structures interacting to keep writing being practised and for it to be emergent, so that it is not regarded as a decontextualised skill that is supposed to be transferable to any situation. In other words, there needs to be an ecology of practices to enable writing practices to flourish.

The development of writing practices becomes possible when practitioners are able to see writing practices and make them visible for their students. Specifically, it is when practitioners believe that writing practices are important and they have sufficient agency to shift the practice architectures of their site of practice to support the practice and development of students' writing. These practices are enhanced when practitioners have professional learning and educational leadership, which influence practice architectures to enable the development of writing practices beyond the site of the local practice. The participants who support writing practices are those who see it as part of the identity of an engineer, and thus it is not in conflict with how they see themselves. In Leyden's terms (2008), their writer selves and their engineering selves are integrated: Bernice, Damien, Eric (for whom research writing is critical) and Harry. The willingness to incorporate writing practices into the learning of content knowledge, and to develop writing practices throughout the curriculum brings to mind comments made by Shove and colleagues about how know-how travels beyond face-to-face interactions. They argue that there is uneven distribution of know-how because it requires people with prior experience to 'decode' the knowledge: 'This suggests know-how can only travel ...to sites in which practitioners are already prepared to receive it because of prior, first-hand, practice-based experience' (Shove, Pantzar & Watson 2012, p. 49). It may be that the propensity to develop writing practices within the context of disciplinary knowledge is linked to the pedagogical understandings of certain practitioners who have 'prior, first-hand, practice-based experience', who are open to seeing writing practices as part of engineering learning because of their previous experience or professional learning. This notion could be explored further in future research.

Human agency, combined with a disposition that recognises oneself as a professional engineer and as an educator, enables writing practices to be developed within and beyond certain sites of practice. This is shown in the case studies of Bernice, Damien and Harry. Although we do not know specifically about the agency of Harry's colleagues in his disciplinary stream, Harry's sayings show that there is collegiality and probably a shared sense of agency – being able to make something happen – in the practices of his colleagues. Damien does not mention his colleagues in the school of integrated engineering; it is quite possible that some of his colleagues lack the agency or desire to develop writing practices, but the practice architectures of integrated engineering course program might override this.

7.3 Contribution to research knowledge

This research is significant for several reasons. Firstly, it contributes to the existing knowledge about writing in engineering; the theoretical lens and methodological approach has provided insights into perspectives of writing practices in the engineering curriculum that have not previously been captured. Furthermore, applying a PAT approach has revealed the narrative of the 'non-writing' engineering curriculum and some of the practice architectures which hold it in place.

The findings of this research are relevant for those who are interested in or involved in engineering education in general, as they demonstrate how a perspective such as PAT can be used to investigate prevailing practices in the engineering curriculum. The findings are also relevant for those who are involved in developing engineering students' communication skills: for policy-makers, engineering educators and ALL lecturers working with engineering faculty staff. As observed in Chapter 2, it is necessary to understand how practices have evolved if one wishes to bring about change. Practice theory perspectives work to uncover '[d]eeply embedded beliefs and taken-for-granted discourses' (Salamon et al. 2014, p. 1). In Chapter 1 I commented that the perspectives of engineering educators about writing practices in the engineering curriculum is an area that has been under-researched; in this study, the perspective provided by practice theory has revealed several previously unspoken narratives about writing practices in engineering.

Along with a theoretical lens and a methodological approach with which to investigate the invisibility of writing practices in the engineering curriculum, PAT has also provided a language with which to talk about this phenomenon, to 'name and unpack' the stories (Pawley 2009) about writing practices in this context. Naming and unpacking can illuminate writing practices and the practices that constrain their development.

I have named writing practices as being invisible in the engineering curriculum; this naming carries a number of implications. Firstly, it implies that writing practices exist in the engineering curriculum, but that they are difficult or impossible to see by most engineering staff and students; they are not recognised. Secondly, it implies that writing practices should be visible. Thirdly, it implies that writing practices should exist – that they belong in engineering studies, that they are part of the necessary knowledge in order to become an engineer, and that they are an element of the engineering identity. Thus, naming writing practices as invisible has the effect of revealing some of the pervasive practices of the engineering curriculum that work together to maintain this invisibility.

In addition to naming writing practices as invisible in the engineering curriculum, this study provides qualitative evidence that these practices exist, beyond the anecdotal evidence that has surrounded this topic for decades. The combination of the metaphor of the invisibility of writing practices and the insights from the perspective of PAT supplies a language with which to discuss these practices. This study suggests that the invisibility of writing practices in the engineering curriculum does not occur by accident; there are complex traditions, beliefs and prevailing practices which interact to keep writing practices invisible. A recognition of the complexity of these practice traditions will assist in developing policies and practices that might make writing practices more durable in engineering studies.

Given that prevailing practices of the engineering curriculum in Australian universities keep writing practices invisible, efforts by individual engineering educators to enable the development of writing practices within their subjects can succeed temporarily, but cannot be sustained without practice architectures to support those efforts. This study has shown not only how writing practices are generally invisible in the sites of practice of the participants, but also how writing can be made visible, and can be developed beyond individual engineering subjects, given the appropriate circumstances.

Writing practices can be made visible if and when they are talked about, acted on and valued as part of the learning of engineering knowledge: the sayings, doings and relatings which are held in place by certain practice architectures. These could include cultural-discursive arrangements which refer to writing as a developmental practice, material-economic arrangements such as faculty policies which state that written and spoken communication should be present in a proportion of engineering subjects in each year of the degree, and social-political arrangements which establish links between subjects so that writing practices in one subject can be built on in subsequent subjects. For this to take place, as in Damien's site of practice, the influence of more than the faculty seems to be required – the social-political and material-economic arrangements of the common curriculum in the field of integrated engineering and of the membership of the national integrated engineering association could well be critical in holding the development of writing practices in place.

One tension that emerges from using the term or metaphor of 'the invisibility of writing practices in the engineering curriculum' is the meaning it can carry. In the current context, writing becomes visible when it is problematic: when it breaks down (Turner 2004; Lillis 2001) and fails to communicate. Such 'visible writing practices' serve to remind engineering educators that they are not trained as 'writing teachers' who are capable of giving corrective feedback about appropriate verb tenses, clause structure and word forms. The visibility that my research refers to is to make writing practices visible within engineering studies, so that they can be spoken about, practised and valued as an element of the learning of engineering knowledge. A desirable outcome might be writing practices that eventually become seamless: invisible in the sense that they are not seen as separate from engineering studies, but are part of what makes an engineer.

7.4 Recommendations from the study

Given the engineering focus on implementing solutions to address needs, it seems appropriate to use the findings of this research to make recommendations to assist faculty who are endeavouring to improve the visibility of writing practices within their curriculum. The qualitative nature of my research militates against generalisability; thus these recommendations for practice are prompted not by objective data but by what I have learned during my research into this topic.

Based on the research presented in this thesis, I recommend considering adopting the following practices to promote supported, sustainable, developmental writing practices embedded in the engineering curriculum.

Institutional support above and beyond the faculty (as seen in the integrated engineering program):

- The cultural-discursive, material-economic and social-political arrangements of a shared curriculum of an engineering program and of a technical writing guide (regularly updated) with examples of writing practices of increasing complexity can create a niche which allows writing practices to flourish

Faculty support

- High level acknowledgement of the relevance of writing practices to the development of a professional or research engineer
- Expectations that the development of writing practices is part of the engineering curriculum
- Recognition that the development of writing practices will need to be factored into the teaching budgets and workloads of engineering educators

At the School or discipline level:

- Educational leadership and pedagogical knowledge to support the development of writing practices as part of learning the practices of the discipline
- Collegial and School level agreement on which stages of development should occur at certain points in the curriculum
- Accountability for the development of writing practices and other professional attributes to be represented in course and subject learning outcomes
- Provision in engineering educators’ workloads for collaborations with faculty colleagues and writing experts
- Collaborative teaching and assessment practices
- Shared resources

- Collegial agreement on the development of writing practices as part of the development of technical knowledge
- Shared language about writing practices and artefacts which can be used throughout an engineering discipline to model increasing complexity of writing practices from first to final year.

7.5 Future directions for research

My understanding of PAT is emergent, as is the theory itself. Members of the Pedagogy, Education and Praxis (PEP) research group are continually expanding and exploring PAT; however, the role of human agency in PAT seems to call for more research. In this regard, the work on agency conducted by language planning policy (LPP) researchers may be of interest. Baldauf and others (Fenton-Smith & Gurley 2016) have developed the following categories of agency: 'people with power, people with expertise, people with influence and people with interest' (2016, p. 74); each group has differing capacities to bring about change. People with power are those with some kind of authority to implement policies; people with influence do not have official power, but can influence the actions of others through their position of respect in a community. People with expertise lack power but have knowledge [of language systems]; people with interest have 'neither power nor personal prestige, but passively or unconsciously [become] involved in making decisions on language use for themselves' (2016, p. 74). Applying these categories to the case studies in this thesis, most of the participants fall into the category of people with interest, but Damien would be regarded as a person with influence and arguably a person with power, as he has had leadership positions in his school. His power and influence can be seen in his site of practice, where there is an ecology of practices that provide a niche in which writing practices can flourish. This suggests that the role of agency (especially those of people with power and influence) in an ecology of practices needs to be explored further. In addition, the work of Deakin Crick and colleagues (e.g. Deakin Crick et al. 2015) on mindful agency could expand our understanding of how agency in teaching practices influences learning. This could be a rich vein for further research, and might add depth to the dimension of agency in PAT, without detracting from the practice theory perspective of focusing on practices.

This study has investigated the invisibility of writing practices in the engineering curriculum; it would be instructive to investigate how writing practices are perceived in engineering practice, both as a comparison and as a way of understanding how best to shift the practice architectures of the engineering curriculum to make writing practices more integrated with learning to become an engineer.

7.6 Limitations of the study

There are several limitations of this study, the first of which applies to qualitative research that seeks to provide rich thick data about particular contexts; the nature of such data means that generalisations are not possible. Despite the lack of generalisability, the value of this approach is its focus on specific sites of practice. Analysis of the site of the local is germane to ontological practice theory perspectives as it provides an understanding of sites of practice and of the practice landscapes in which the sites of practice are located, both spatially and temporally. While findings from research based on a small number of case studies cannot necessarily be applied to Australian engineering faculties in general, the descriptions of the practices in the case studies gives insights which can be more broadly interpreted. Furthermore, as the case studies were from five different institutions in three Australian states/territories, they reveal prevailing practices beyond one institution or state, suggesting that there are indeed commonalities in the practice landscapes of Australian engineering faculties that are likely to render writing practices invisible.

The use of PAT as a theoretical and methodological perspective both enabled and constrained my interpretation and understanding of the data; by considering the research questions through the lens of practice theory, I was less inclined to consider other perspectives.

Another limitation is that I decided to use PAT as a theoretical and methodological approach after I had commenced analysing the data. Nevertheless, the application of firstly activity theory and then PAT meant that the data were analysed through two complementary theoretical lenses, which provided a deeper understanding of the research questions and of the case studies.

The importance of human agency emerged as one of the key factors in constraining or developing writing practices in the case studies. However, these findings are strongly influenced by the methodology of the study, which used individual engineering educators' sites of practice as the unit of analysis, rather than networks of practices within the practice landscapes of the sites of practice. A study using a single faculty or school of engineering as a site of practice to investigate how writing practices are developed within that site would reveal different practices and practice architectures, and may not emphasise individual agency to the same extent. An illustration of this can be seen in Bernice's case study. Bernice demonstrates significant agency in the teaching and assessment practices in her site of practice, which strongly support the development of her students' writing practices. She critiques the teaching and assessment practices of her colleagues in her school of engineering (University A), for not providing similar (or any) support in the subjects that they teach. In her interview she points out that other subject coordinators do not provide opportunities for students to learn about writing practices or to practise writing, and that the assessment practices de-emphasise the importance of good writing practices. However, without examining and analysing the sites of practice of her colleagues, her comments remain unsupported by evidence. Bernice may regard herself as isolated from her colleagues, and see her practices as not being supported by other practices in her school, but there may be other practice architectures within or beyond the school which could provide a different analysis.

7.7 Thesis conclusion

> ...naming the narratives also helps make them available for critical analysis. If we as engineering educators fail to name and unpack our own stories, we risk carrying on the way 'it's always been done,' maintaining the discipline upon its historical and arguably exclusive foundation. (Pawley 2009, p. 317)

The quotation above from Alice Pawley's study of engineering educators encapsulates much of what this thesis has endeavoured to do – to 'name and unpack' the stories around writing practices in the engineering curriculum, especially those stories which portray engineering students as naturally poor or reluctant writers, and thus problematic – the deficit model, as discussed in chapter 2. By examining the practices in the case studies of the participants in this study, I have sought to shift the focus from problematic students to problematic practices, to consider how writing practices are frequently unregarded and underdeveloped.

I set out to analyse critically how writing practices are rendered invisible, and to provide a language with which to make these practices visible, and able to be thought about and discussed. Without this naming and critical analysis, the myths and realities of the 'non-writing' engineering curriculum are likely to prevail. One consequence is engineering graduates who may lack both strong writing practices and the awareness of the role these practices play in engineering practice and research. Of at least equal significance, the majority of engineering educators will continue to regard the development of writing practices as 'not their job'; furthermore, engineers will continue to be seen - within their own profession and in the general community – as narrow technical specialists, not as social actors who are expected to be commentators and critics of policies and projects.

Overall, this study has found practices and practice architectures that constrain writing practices in the engineering curriculum. It has employed PAT to illuminate some of the hidden narratives of these practices, and has identified ecologies of practices where writing practices struggle to thrive. It has also found an ecology of practices that allows writing practices to flourish within an engineering degree program.

What can be taken from this research is the provision of a language, a shift in focus and some recommendations so that researchers and practitioners can talk about practices beyond the individual subject coordinators, while recognising the importance of agency of individual and collective actions. Building on the findings of this study, there are opportunities for further research into what it takes to develop an ecology of practices to support writing practices within and beyond a disciplinary stream. There are also opportunities for further research into the role and nature of agency in PAT, and of the gendered nature of writing in engineering, adding to the studies of gender in engineering.

Appendices

Appendix A: Ethics approval and participation forms

HREC Approval Granted

Fri 28/02/2014 11:35 AM

Keith Willey <Keith.Willey@uts.edu.au>; Rosalie Goldsmith <Rosalie.Goldsmith@uts.edu.au>; Research Ethics <research.ethics@uts.edu.au>

Dear Applicant

Thank you for your response to the Committee's comments for your project titled, 'Increasing the visibility of writing in engineering'. Your response satisfactorily addresses the concerns and questions raised by the Committee who agreed that the application now meets the requirements of the NHMRC National Statement on Ethical Conduct in Human Research (2007). I am pleased to inform you that ethics approval is now granted.

Your approval number is UTS HREC REF NO. 2013000398
Your approval is valid five years from the date of this email.

Please note that the ethical conduct of research is an on-going process. The National Statement on Ethical Conduct in Research Involving Humans requires us to obtain a report about the progress of the research, and in particular about any changes to the research which may have ethical implications. This report form must be completed at least annually, and at the end of the project (if it takes more than a year). The Ethics Secretariat will contact you when it is time to complete your first report.

I also refer you to the AVCC guidelines relating to the storage of data, which require that data be kept for a minimum of 5 years after publication of research. However, in NSW, longer retention requirements are required for research on human subjects with potential long-term effects, research with long-term environmental effects, or research considered of national or international significance, importance, or controversy. If the data from this research project falls into one of these categories, contact University Records for advice on long-term retention.

You should consider this your official letter of approval. If you require a hardcopy please contact Research.Ethics@uts.edu.au.

To access this application, please follow the URLs below:
* if accessing within the UTS network: http://rmprod.itd.uts.edu.au/RMENet/HOM001N.aspx
* if accessing outside of UTS network: https://remote.uts.edu.au , and click on 'RMENet – ResearchMaster Enterprise' after logging in.

We value your feedback on the online ethics process. If you would like to provide feedback please go to: http://surveys.uts.edu.au/surveys/onlineethics/index.cfm

If you have any queries about your ethics approval, or require any amendments to your research in the future, please do not hesitate to contact Research.Ethics@uts.edu.au.

Yours sincerely,

Professor Marion Haas
Chairperson
UTS Human Research Ethics Committee
C/- Research & Innovation Office
University of Technology, Sydney
T: (02) 9514 9772
F: (02) 9514 1244
E: Research.Ethics@uts.edu.au
I: http://www.research.uts.edu.au/policies/restricted/ethics.html
P: PO Box 123, BROADWAY NSW 2007
[Level 14, Building 1, Broadway Campus]
CB01.14.08.04

Ref: E11¿

INVITATION LETTER

Perceptions of writing in the engineering curriculum UTS HREC Approval No. UTS HREC REF NO. 2013000398

Dear ,

My name is Rosalie Goldsmith and I am an academic and research student at the University of Technology, Sydney (UTS). I am part of a research team that includes Dr Keith Willey and Professor David Boud from UTS.

We are conducting research into the perceptions of engineering academics about writing in the engineering curriculum, so that we can better understand how to make engineering writing practices more visible. We would welcome your assistance. We are looking for engineering academics who are currently coordinating engineering subjects.

The research will involve providing access to your subject outline and any related documents such as learning guides, descriptions of assessment tasks, and student writing samples (if available), followed by an interview where you will be invited to discuss your perceptions about writing in engineering. The interview should take no more than one hour of your time.

If you are interested in participating, could you please contact me by return email at rosalie.goldsmith@uts.edu.au

You are under no obligation to participate in this research.

Yours sincerely,

Rosalie Goldsmith
Lecturer
Academic Language and Learning, IML
Office of the Deputy Vice-Chancellor (Teaching, Learning & Equity)
University of Technology, Sydney
Tel. +61 2 9514 1654
rosalie.goldsmith@uts.edu.au

NOTE:

This study has been approved by the University of Technology, Sydney Human Research Ethics Committee.

If you have any complaints or reservations about any aspect of your participation in this research which you
cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 9772 Research.Ethics@uts.edu.au), and quote the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

INFORMATION SHEET
Perceptions of writing in the engineering curriculum UTS HREC REF NO. 2013000398

WHO IS DOING THE RESEARCH?

My name is Rosalie Goldsmith and I am an academic and research student at UTS. My supervisor is Dr Keith Willey.

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about the perceptions of engineering academics about writing in the engineering curriculum, so that we can better understand how to make engineering writing practices more visible.

IF I SAY YES, WHAT WILL IT INVOLVE?

I will ask you to provide me with your subject outline and any related documents such as learning
guides, descriptions of assessment tasks and student writing samples (if available). I will then arrange an interview with you at your convenience, in a meeting place of your choice. I will invite
you to discuss your perceptions about writing in engineering. The interview should last no more than one hour, and will be audio-taped. I may also contact you via email with follow-up questions.

ARE THERE ANY RISKS/INCONVENIENCE?

While no harm is intended, invasion of privacy, embarrassment or distress may result in unforeseen ways. You will be discussing your perceptions which may require some level of personal disclosure.

WHY HAVE I BEEN ASKED?

As an engineering academic who is currently teaching, you are in a position to provide important
insights into your perceptions of writing in the engineering curriculum and about the writing that your students do in your subject.

DO I HAVE TO SAY YES?

You don’t have to say yes. Participation is completely voluntary, and you can withdraw at any time, for any reason, without prejudice.

WHAT WILL HAPPEN IF I SAY NO?

Nothing. I will thank you for your time so far and won’t contact you about this research again.

IF I SAY YES, CAN I CHANGE MY MIND LATER?

You can change your mind at any time and you don’t have to say why. I will thank you for your time so far and won’t contact you about this research again.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us on: Ms Rosalie Goldsmith: 02-95141654; Dr Willey: 02 9514 7605.
If you would like to talk to someone who is not connected with the research, you may contact the
Research Ethics Officer on 02 9514 9772, and quote this number *UTS HREC REF NO. 2013000398*

CONSENT FORM

I ____________________ *(participant's name)* agree to participate in the research project ______________________ *('Perceptions of writing in the engineering curriculum' HREC Approval No. 2013000398)* being conducted by being conducted by Ms Rosalie Goldsmith, c/- PO Box 123, Broadway, Ultimo NSW 2007, 02 95141654 of the University of Technology, Sydney
for her PhD.

I understand that the purpose of this study is to investigate the perceptions of engineering academics about writing in the engineering curriculum, so that we can better understand how to make engineering writing practices more visible.

I understand that I have been asked to participate in this research because I am an engineering academic currently teaching, and that my participation in this research will involve providing the researcher with my subject outline and any related documents such as learning guides, descriptions of assessment tasks and student writing samples (if available). It will then involve an interview with me at my convenience, in a meeting place of my choice, to discuss my perceptions about writing in engineering. The interview should last no more than one hour, and will be audio-taped. I may also be emailed after the interview for clarification purposes. I understand that the researchers have designed the process to minimise risks, but that there is a small risk of the interview generating slight negative feelings such as embarrassment.

I am aware that I can contact Rosalie Goldsmith or her supervisor Dr Keith Willey if I have any concerns about the research. I also understand that I am free to withdraw my participation from this research project at any time I wish, without consequences, and without giving a reason.

I agree that Rosalie Goldsmith has answered all my questions fully and clearly

I agree that the research data gathered from this project may be published in a form that does not
identify me in any way.

____ ____/____/____
Signature (participant)

____ ____/____/____
Signature (researcher or delegate)

NOTE:

This study has been approved by the University of Technology, Sydney Human Research Ethics Committee.

If you have any complaints or reservations about any aspect of your participation in this research which you
cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 9772 Research.Ethics@uts.edu.au) and quote the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix B: Interview questions

Semi-structured interview questions

1. Describe what goes on in your subject.
2. What are the main learning outcomes of your subject?
3. *One of the learning outcomes is report writing: how do the students learn that?*
4. *What assumptions do you make about any prior experience or knowledge they might have?*
5. What kinds of writing do students do in your subject/s?
6. What are the writing tasks, and what other kinds of writing do students do?
7. *I can see that the students have to write a report. How do you assess the writing? Can you describe the qualities you're looking for?*
8. Who marks the students' writing/assignments?
9. What do you comment on?
10. What do you assess?
11. What qualities do you look for?
12. What feedback do you give?
13. What opportunities are there for students to practise their writing?
14. Can you see writing being developed (from beginning to end of semester; from one subject to the next)?
15. (What do you see to be the purposes of writing in your subject?)
16. How do the writing practices in your subject prepare students for the writing practices of engineering?
17. How do your students learn or acquire engineering writing practices?
18. How do you ensure that students are aware of the standard of writing required for engineering practice?
19. What are your writing practices as an engineer?
20. How did you learn to do these tasks?
21. What kinds of writing did you do/have you done as a practising engineer?
22. How did you learn to do the different kinds of writing?
23. How do you model engineering writing practices for your students?
24. How would you describe the writing practices in the engineering curriculum?
25. Do you think students can develop their writing practices in this curriculum?
26. Do you think students should be able to develop their writing practices in the curriculum?
27. Do your views reflect the faculty view?

Appendix C: Selected publications and presentations

Goldsmith, Rosalie & Willey, Keith. (in press), 'Making writing practices visible and sustainable in the engineering curriculum: a practice architectures theory analysis', Proceedings of the Canadian Engineering Education Association Conference, University of British Columbia, Canada, 3 – 6 June, 2018.

Making writing practices visible and sustainable in the engineering curriculum: a practice architectures theory analysis

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University of Technology Sydney[1], University of Sydney[2]
Rosalie.goldsmith@uts.edu.au

Abstract: Engineering practice requires engineers who have strong spoken and written communication skills, but the development of these skills, notably writing practices, is often invisible in the engineering curriculum, and rarely embedded. Decades of reviews of engineering education have identified the gap between the engineering curriculum and engineering practice, such as engineering graduates' level of writing skills being inadequate for the workplace. This paper draws on research from a qualitative study which investigates the perspectives of engineering educators about writing practices in the engineering curriculum, utilizing the theory of practice architectures as a theoretical and methodological lens. Using examples from the case studies, we explore some constraints of the development of writing practices in the engineering curriculum. We then focus on case studies where the development of writing practices is enabled within a subject, across a sequence of subjects and throughout an engineering degree program, and identify elements that contribute to these practices. Our findings suggest that the development of writing practices can be integrated into engineering studies, but certain pre-conditions are required.

Keywords: engineering writing, practice architectures theory, engineering curriculum

1. INTRODUCTION

1.1. Motivation for the paper

Engineering practice requires engineers to create, innovate, collaborate, coordinate and communicate. As part of their everyday practice engineers need to reason, argue, explain, discuss, negotiate, recommend, justify and evaluate, both orally and in writing. However, there is a significant gap between the writing practices in the engineering curriculum and those of engineering practice, which has been identified in studies and reviews of engineering education, for example [1]; [20]; [24]; [27]; [28]; [29]; [32]; [36]; [39]. Several researchers note that employers are disappointed by engineering graduates' lack of 'business-specific writing' [20] and a lack of adaptability to the writing skills needed in the workplace [1]. According to accrediting bodies such as ABET, Engineers Australia (EA), and the Engineering Council (UK), and by the engineering faculties that teach engineering, the attainment of written and spoken communication skills in engineering students is an intended outcome of the engineering curriculum: 'Effective oral and written communication in professional and lay domains' [7, p.2]. Employers expect engineering graduates to be able to communicate clearly and professionally. 'The expected abilities for communicating clearly include… being concise; giving sufficient explanation; and giving clear, high-level overviews' [34 p.138].

Nevertheless, writing practices continue to be invisible in the engineering curriculum. While some engineering educators and writing instructors have worked tirelessly to help students develop their writing, the traces of this work are hard to detect over time, suggesting that the problem may lie more within the engineering curriculum than with engineering students.

1.2. Literature review

It is difficult to ascertain where writing practices are developed within the engineering curriculum, even with a close examination of subject outlines or by mapping graduate attributes. Such investigations can reveal where writing does or does not take place, but may not indicate how writing in the context of the subject is practised, nor the level of writing practice required. There may be excellent writing practices in one engineering subject but these may not be developed in subsequent subjects. For example, first year engineering students at two Australian universities are not required to do any writing except for notation for six of the eight subjects (University A) and for seven of the eight subjects (University B) [12], and this trend continues in later year subjects. If writing practices are introduced, they are usually located in one or two subjects that are seen to be the domain of 'soft skills' development (engineering management, engineering communication), rather than being seen as part of the technical knowledge of content areas [5]; [17]. This both isolates writing practices as not being part of 'real engineering' and limits the opportunities for their development. The continued existence of writing practices is not guaranteed, even in subjects where they have been embedded; changing circumstances (staffing, student numbers, budgetary constraints) can quickly cause them to be no longer practised, or to be downgraded to de-contextualised written artefacts.

Such an under-representation of writing either as process (practice) or as product (artefact) does not reflect what occurs in engineering practice. It suggests that those who enact the engineering curriculum do not see writing (whether in an instrumental function or as a vehicle for learning) as being an explicit element of the curriculum. The emphasis appears to be on the transmission of engineering science knowledge, as noted in several studies over the last few decades (e.g. [10]; [20]; [24]; [31]; [40]). Furthermore, it is unclear who is responsible for the development of writing practices, nor is it clear who among engineering educators feels confident to do so [11]; [22]; [29]; [36].

Both the lack of visibility of writing practices in the engineering curriculum and the uncertainty about whose role it is to develop the graduate attribute of communication highlight gaps in the research in the role of engineering educators in this regard. Much of the literature focuses on initiatives for engineering students to develop or improve their writing, often with assistance from an academic language and learning (ALL) instructor, within a subject or across an engineering program. Many of the strategies reported in the literature are optional adjunct subjects or resources [4]; [8]; [13]; [14]; [25] [28]; [31]; [36]; [37]; [41] (see also [29] for their comments on the number of publications on developing engineering students' writing). Literature on the perspectives of engineering educators about developing writing practices is less common and mainly examines the research writing practices of engineering educators and of their research students [6]; [9]; [21]; (see also [3]), or the writing of practising engineers [44] and of engineering students becoming novice engineers [2]; [45].

Studies which have examined engineering educators' perspectives of writing in the curriculum include Jenkins, Jordan and Weiland [16], who surveyed engineering faculty staff about their beliefs and practices of engineering writing in the context of the role of writing in postgraduate engineering subjects in US universities. Zhu [46] compared business and engineering faculty members' views of student writing in their respective disciplines in one US university. Zhu's [46] primary concern, like that of Jenkins et al. [16], is how to support ESL students in their disciplinary writing. Both studies have a similar context: they are set in American universities, where there are specific programs of writing instruction for all students, unlike Australian universities. An Australian context for the engineering faculty perspectives of writing is provided by Howard and colleagues [15], who examined engineering educators' views about writing and online tools to support the development of engineering students' communication capabilities. All three studies found that writing is seen as important for engineering students, but how students develop their writing practices is not the typical concern of engineering faculty.

The conception of engineering as being solely or mainly about cutting edge technology and technical fixes occurs frequently in popular culture, and in promotional materials for engineering subjects at university: images of robots and rockets tend to feature heavily. Engineers do not come across as having excellent coordination and communication skills, nor do these images represent 'a creative activity based on science, mathematics and technical knowledge applied with art...' [7, p.8]. In fact, there is a tension between practising engineers and engineering educators about the focus on engineering science in the curriculum and the lack of emphasis on developing professional attributes, as noted in [20 p.68].

1.3. Problem definition

It can be seen from the review of the literature that there are significant gaps in our understanding of how writing practices are perceived and developed in the engineering curriculum. Thus the purpose of this study is to investigate what makes writing practices invisible in the curriculum; to problematise the idea of the 'non-writing engineering curriculum'; to see how prevailing practices in the engineering curriculum constrain rather than enable writing practices. By exploring this problem, writing practices can become visible and a language is provided with which to discuss review the issues. Without this visibility and this language, writing practices in the engineering curriculum will continue to struggle to be seen as an integral practice of learning to become a professional engineer.

2. METHOD AND METHODOLOGIES

The current study examines some constraints and enablers of the development of writing practices in the engineering curriculum. It has an Australian focus, but as is shown in the literature, similar challenges occur around writing practices in other engineering education contexts (e.g. [1]; [8]; [23]; [30]; [39]). A case study methodology was used in combination with practice architectures theory to analyse how writing is practised in engineering subjects (also referred to as courses or units in Australian universities).

The study uses practice architectures theory as both a theoretical perspective and a methodological lens. Practice architectures theory (PAT) (e.g. [18]) has evolved from Schatzki's practice theory (e.g. [35]), 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 [26 p. 9]). In this study, sites of practice are the engineering subjects taught by the participants. 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 (the doings) 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 [19]. 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.

Nine engineering educators who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities were recruited from five institutions in three states; 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 collected. The documents were analysed to identify practices of teaching, learning and assessment, 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. The interviews were transcribed and analysed to identify emergent themes using Concordance software [42] which identifies frequency of occurrence of words.

These themes were then re-analysed to identify elements of practices. Three participants agreed to being observed while teaching; the first author attended their lectures or tutorials and took notes, which were later transcribed. As per ethical requirements, all participants have been de-identified and are referred to by pseudonyms; their institutions are referred to by letters.

3. RESULTS AND DISCUSSION

In this paper we first discuss practices that do not support the development of writing practices within engineering subjects, with examples taken from sites of practice. We then present examples where writing practices are supported and developed not only within an engineering subject but across several subjects, and throughout an engineering discipline. We discuss the practice architectures that hold these practices in place, and consider the conditions that allow these practices to flourish. Our findings suggest that the development of writing practices can be integrated into engineering studies, but certain pre-conditions are required.

3.1. Unsupported writing practices

An unsupported practice of writing is where the practice architectures and elements of practice provide no space for writing practices. Instead all the space is taken up with practices that support the teaching and learning of technical knowledge. Shove, Pantzar and Watson [38] claim that practices are in competition for time and space, and argue that 'practitioner-time [is]…a necessarily limited, inherently finite resource, the allocation of which reflects the relative dominance of some practices over others…' (p.127). This competition is enacted in the sites of practice in this study and is evident in the sayings of the participants when they talk about how little time there is to cover all the topics in the subject and the cost of marking written assignments compared to marking quizzes. The majority of the case studies showed evidence of unsupported or fragmented support for writing practices. Table 1 summarises some of the unsupported writing practices.

Table 1: Unsupported writing practices

A lack of meta-language with which to talk about writing practices; unhelpful or non-existent feedback on written assignments (cultural-discursive)
No opportunities for students to practise writing during classes (material-economic)
No time allocated to developing writing practices in class or for homework (material-economic)
Minimal assessment weighting given to the quality of writing (material-economic)
Little/no observable agency on the part of the engineering educator to enact elements of practice that would enable students to practise writing (social-political)
No visible links between one subject and the next, or between the writing practices developed within one subject and what might be practised or expected in subsequent subjects (social-political)

The following paragraphs discuss unsupported writing practices in two of the case studies, those of Felicity and Garth. Felicity (from University C) teaches a technical third year electrical engineering subject; the cohort size is approximately 110. The subject is 'a core unit [subject] that develops fundamental electrical circuit concepts essential for an electrical engineer' (Felicity subject outline 2014 p.1). The assessment of the subject consists of: in class quizzes (10%); a problem-solving task (group assignment) 40%; laboratory/practical experiments (10%) and a final exam (40%).

There are five learning outcomes listed in Felicity's subject outline; not surprisingly in a later year technical subject the emphasis is on the acquisition of technical knowledge, but learning outcomes 3 and 4 are worded as though they would require students to write discursively.

3. Identify fundamentals of power system economics, generation costs, tariffs, market rules and performance
4. Explain principles of single and three phase transformers operation and performance (winding, testing, losses and efficiency) (Felicity subject outline p.2).

In addition, the description of the final examination for this subject implies that students would be expected to produce answers involving extended writing: 'The final exam [written] of two hours in length will be aimed at evaluating problem formulation, general knowledge and the relationships of fundamental knowledge to the systems studied' (Felicity subject outline p.3). However, there is no mention in the subject outline, nor in the interview, nor in the assessment documents, of writing, and no examples of it being practised – neither in the practice architectures nor in the practices. It appears that students will be expected to acquire learning outcomes that assume writing as negotiated meaning, and will be tested on this, at least implicitly, but without the opportunity to practise this kind of writing. The writing of numbers (equations, formulae and calculations) is present, but this is not seen as writing by Felicity and may not be seen as writing by students, as demonstrated by what she says:

…rather than writing a report or providing some document they need to attempt different examples, questions during tutorial sessions…So - not for this case, for this unit [subject] - they do not need to write lots of reports… (Felicity interview)

The practice architectures – the cultural-discursive, material-economic and social political arrangements and the elements of the practice –the sayings, doings and relatings – support the learning of technical knowledge. This is enacted by language, activities and the value put on technical knowledge. At the same time, the practice architectures and elements of practices within Felicity's site constrain the practice of writing. In this site of practice, writing other than notation is invisible, and perhaps does not occur. The practice of encouraging students to explain technical concepts in words as well as in numbers does not take place. In other words, the emphasis on the technical knowledge of the discipline in Felicity's site does not allow writing to be thought of as part of learning electrical circuit concepts; the cultural-discursive arrangements are 'constraining what it is relevant to say' [19, p.32] or to think about the practice of writing in electrical engineering. Felicity's sayings focus on the technical knowledge that the students are acquiring, even when she is specifically asked about their writing practices; the examples she gives are figures and screenshots of results, not words. The assignments are projects with reports but the emphasis is on accuracy of calculations and solutions, not on explanations or evaluations.

Another example of unsupported writing practices can be seen in Garth's case study (University C), who teaches a third year civil engineering subject (cohort size about 300) where the 'problem based learning projects' (Garth subject outline 2014 p.3) are in fact questions that require mathematical equations. Garth acknowledges that he changed the focus of the student project to emphasise solving mathematical problems because:

…we have too many things that we want to teach and we only have 13 weeks. So we...use tutorial times...to teach something. So I thought that is the best way to utilise the time but by doing that there's no practice actually for a student to improve their writing skill (Garth, interview).

Garth's comment here epitomises the practice architectures around writing practices in the engineering curriculum, and the view espoused by many engineering educators: writing practices are described as important until they compete for scarce resources and for status– the material-economic arrangements and the social-political arrangements in the engineering curriculum of space and relevance within the curriculum, of time on task, of teaching time, of the time taken to mark assessment tasks, and then they become less important. Because of these pressures, it becomes unthinkable and undoable to have writing practices take up space in the teaching activities of his subject, 'because there are so many other important things that we want to include and teach' (Garth interview). There is too little time in the class or the semester, or it is not someone's job to teach writing, or writing is important but not quite as important as the technical knowledge taught by the subject coordinator.

We argue that in such circumstances, writing is not a practice but an activity. It is difficult to find evidence of opportunities for students to practise writing in tutorials or laboratory sessions, in contrast to the time allocated to practising calculations and doing worked examples of problems. Unlike the development of students' technical or technical knowledge, writing is mostly not practised formatively. However, it is assessed summatively in the reports that students are asked to produce, indicating that the view of 'the write-up', as opposed to the view of writing as a practice, is alive and well.

3.2. Supported writing practices

The practice architectures of the case studies where writing as a practice is visible and supported beyond the local site are formed by a complex interaction of pedagogical practices, collegial practices, and agency of the participants. These practice architectures are summarized in Table 2. A few of the case studies had fragments of these arrangements, but not sufficiently to support writing practices within their site of practice.

Table 2: supported writing practices in the engineering curriculum

Writing spoken of and thought of as a practice; written communication a specific learning outcome of the subject (cultural-discursive arrangements)
Writing practised in class or online; writing given formative or summative feedback; writing modelled and/or exemplars provided; writing given specific weighting in assessment tasks (material-economic arrangements)
Writing part of the subject assessment; writing practices part of the identity of the professional engineer; writing practices linked to other subjects in the curriculum (social-political arrangements)

The three case studies which evidence supported writing practices either within or beyond their site of practice are: Bernice (university A); Harry (University D) and Damien (university B). The pedagogical practices include: participants talking about writing practices as being key to learning (sayings); their students enacting writing practices in class time or for assignments (doings); providing formative feedback to their students (doings) and demonstrating knowledge of writing practices in subjects taught by their colleagues (relatings). The collegial practices of the participants involve working with engineering colleagues to extend the writing practices beyond their sites, and allowing the practice of writing to be seen as developmental.

While two of the case studies supported writing practices within their site of practice (Bernice) or across sequential subjects (Harry), only one case study (Damien) provides an example of supported practices that extend throughout the engineering degree program in his school. Damien is a professor in the school of X engineering at University B and has been an engineering educator for some years, with prior experience in industry. This school belongs to a discipline of engineering that has a common curriculum shared by several Australian universities for years 3 and 4 of the Bachelor degree. He teaches a second year subject in X engineering.The cohort size is approximately 80 students. The assessment tasks for this subject are: 2 numerical reports worth 20% and 5%, two field reports worth 15% and 30% each and a final examination worth 30% (Damien subject outline 2014, p.7). The first field report is preliminary, to provide students with formative feedback. The second report is based on the first one.

There are four learning outcomes of Damien's subject; the fourth one states: "students are expected to be able to...prepare a technical report that presents the results of a study on a [X] project that is consistent with the requirements and standards of the School of [X] Engineering and relevant professional society" (Damien's subject outline 2014, p.3). The practice architectures and practices of Damien's site interact to provide extensive support for writing practices within and beyond this site. Most striking is the report writing guide, used by all the Australian engineering faculties sharing the common curriculum of X engineering discipline, and to which Damien has made significant contributions. It is a substantial document (84 pages) which provides extensive information about the field-specific requirements of engineering reports in terms of content, format, language and presentation, with exemplars, and was in its ninth edition at the time of this study. The existence of the report writing guide prefigures the perception by students and staff that writing is a practice, and that writing reports is an integral practice in the discipline of X engineering. The practice of revising the report writing guide demonstrates that writing practices are developmental and emergent, not fixed [33]. None of the other case studies in this research has an artefact like the report writing guide; at best there are learning guides or assignment guidelines which are specific to the subject and which would probably fall into disuse if the subject coordinator moved on to another subject or to another institution.

The cultural-discursive arrangements of Damien's site support his sayings about the relevance of writing practices to the study of X engineering. The subject outline includes assessment criteria for the assignments which specifically mention "Interpretation of information and calculations" and "Discussion and demonstration of further research" (Damien subject outline 2014, p.9). The practices include a lecture given by to all first year students enrolled in the school of X engineering and the report writing guide.

Two of the assessment items in Damien's subject require students to write reports that require them to discuss and interpret observations or results. Report writing is practised and scaffolded in Damien's subject and is developed through the major in which his subject is situated. Students receive explicit information about what is required in the writing of the report (with exemplars in the guide) and formative feedback. They also have the opportunity to practise their writing, both with the preliminary report: "The idea of the preliminary report is for the students to have two turns at writing the report" (Damien interview) and through an open-access online report writing site with self-paced activities which features an engineering field report (Learning Centre University of Sydney 2012).

Damien refers to the 'cycle' of report writing that the students experience as they progress through their degree, and demonstrates his awareness of the developmental nature of writing practices, as the following comment illustrates:

Even introducing the first year, by the time they get to the fourth year it doesn't necessarily mean they can write good reports (Damien, interview).

The social-political arrangements and relatings in Damien's site of practice are notable – both Damien's leadership and the presence of the common curriculum within X engineering schools in different universities are unusual in the case studies, and powerful in the way that they hold the practices of report writing in place.

4. CONCLUSION

In conclusion, the analysis of Damien's case study using the lens of practice architectures theory shows that writing practices can be made visible if and when they are talked about, acted on and valued as part of the learning of engineering knowledge: the sayings, doings and relatings which are held in place by certain practice architectures. These include cultural-discursive arrangements which refer to writing as a developmental practice, material-economic arrangements such as faculty policies which state that written and spoken communication should be present in a proportion of engineering subjects in each year of the degree, and social-political arrangements which establish links between subjects so that writing practices in one subject can be built on in subsequent subjects. For this to take place, as in Damien's site of practice, the influence of more than the faculty seems to be required – the social-political and material-economic arrangements of Damien's educational leadership, the common curriculum in the field of X engineering and of the membership of the National X engineering association could well be critical in holding the development of writing practices in place. This could be a rich vein for further research.

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REFERENCES

1. Appleby Y., Roberts S., Barnes L., Qualter P., Tariq V. Who wants to be able to do references properly and be unemployed? STEM student writing and employer needs. *Journal of Learning Development in Higher Education*. 2012. Special Edition, November 2012.
2. Artemeva N. Stories of becoming: A Study of novice engineers learning genres of their profession. In: C. Bazerman AB, & D. Figueiredo editors. *Genre in a Changing World*. Colorado: The WAC Clearinghouse; 2009.
3. Blakeslee A.M. Activity, context, interaction and authority: Learning to write scientific papers in situ. *Journal of Business and Technical Communication*, vol 11, no. 2, 125-69, 1997.
4. Carter M., Ferzli M., Wiebe E. Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*. Vol.21, 2007.
5. Colman, B., & Willmot, P. How soft are 'soft skills' in the engineering profession? *44th SEFI Conference*, Tampere, Finland, 2016.
6. Curry, M.J. Graphics and invention in engineers' writing for publication. In M.J. Curry & D.I. Hanauer, (Eds), *Language, literacy and learning in STEM education*. Amsterdam: John Benjamins; 2014, pp. 87-106.

7. Engineers Australia. *Stage 1 competency standard for professional engineers* 2013. https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/130607_stage_1_pe_2013_approved.pdf.
8. Fischer, A. 'Hidden features' and 'overt instruction' in academic literacy practices: A case study in engineering. in T. Lillis, K. Harrington, M.R. Lea & S. Mitchell (Eds.), *Working with academic literacies*. WAC Clearinghouse, Colorado, 2015. Retrieved from https://wac.colostate.edu/.
9. Gimenez, J.. Writing as social practice in engineering: Views from a cross-disciplinary study. In In M.J. Curry & D.I. Hanauer (Eds.), *Language, literacy and learning in STEM education.* Amsterdam, John Benjamins. pp.87-106, 2014.
10. Goldberg, D. *The Big Beacon Manifesto,* 2011. http://bigbeacon.org/big-beacon-manifesto.pdf
11. Goldsmith, R., & Willey, K. "It's not my job to teach writing": Activity theory analysis of [invisible] writing practices in the engineering curriculum. *Journal of Academic Language & Learning,* vol. 10, no.1, pp. A118-A129, 2016.
12. Goldsmith, R., Willey, K. & Boud, D.. How can writing develop students' deep approaches to learning in the engineering curriculum? *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria, 2012.
13. Herrington, A.J., "Writing in Academic Settings: A study of the contexts for writing in two college chemical engineering subjects", *Research in the Teaching of English*, vol. 19, no.4, pp. 331-361, 1985.
14. Hilgers, T.L., Hussey, E. & Stitt-Bergh, M., "'As you're writing, you have these epiphanies': What college students say about writing and learning in their majors", *Written Communication,* vol. 16, pp. 317-353, 1999.
15. Howard, S., Khosronejad, K. & Calvo, R., Exploring Engineering instructors' views about writing and online tools to support communication in Engineering, *European Journal of Engineering Education*, 2016. {DOI: 10.1080/03043797.2016.1228612}.
16. Jenkins, S., Jordan, M.K. & Weiland, P. O. The role of writing in graduate engineering education: a survey of faculty beliefs and practices, *English for Specific Purposes*, *12*, 51-67, 1993.
17. Johnston, S., & McGregor, H. Recognising and supporting a scholarship of practice: Soft skills are hard! *Proceedings of the 15th AAEE Conference*, Toowoomba, Australia, 2004.
18. Kemmis, S. & Mutton, R. Education for sustainability (EfS): practice and practice architectures. *Environmental Education Research*, vol.18, no.2, pp. 187-207, 2012.
19. Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L. *Changing Practices, Changing Education*. Singapore: Springer, 2014.
20. King, R., *Engineers for the Future: addressing the supply and quality of Australian graduates for the 21st Century*, ALTC, 2008. http://www.olt.gov.au
21. Koutsantoni D. *Developing Academic Literacies: Understanding Disciplinary Communities' Culture and Rhetoric*. Bern, Switzerland, Peter Lang, 2007.
22. Kranov, A. A. 'It's not my job to teach them how to write': Facilitating the disciplinary rhetorical socialization of international ESL graduate assistants in the sciences and engineering. *ASEE 2009 Annual Conference & Exposition*, Austin, Texas, 2009.
23. Leydens, Jon A.. Novice and insider perspectives on academic and workplace writing: Towards a continuum of rhetorical awareness, IEEE Transactions on Professional Communication, vol.51, no.3, September, 2008.
24. Lloyd, B., Rice M., Ferguson, C., Palmer, S. *Engineering the Future: Preparing professional engineers for the 21st century*. Brighton East, Victoria, Association of Professional Engineers, Scientists and Managers, Australia, 2001.
25. Lord, S.M. Integrating effective 'writing to communicate' experiences in engineering subjects: Guidelines and examples. *International Journal of Engineering Education,* vol. 25, no.1, pp. 196-204. 2009.
26. Mahon K., Kemmis S., Francisco S. & Lloyd-Zantiotis A. Introduction: Practice Theory and the Theory of Practice Architectures. In: K. Mahon, S. Francisco & S. Kemmis (Eds.), *Exploring education and professional practice: Through the lens of practice architectures*. Singapore: Springer, p. 1-30, 2017.
27. Male, S.A., Bush, M.B., & Chapman, E.S. "An Australian study of generic competencies required by engineers", *European Journal of Engineering Education*, vol. 36, no.2. 2011
28. Mort, P., & Drury, H. Supporting student academic literacy in the disciplines using genre-based online pedagogy. *Journal of Academic Language and Learning*, vol.6, no.3, pp.A1-A15, 2012.
29. Mort P., Drury H., Calvo R., Skinner I., McEwan A., & Levy D. An online writing centre for engineering students. *Proceedings of the 8th International CDIO Conference*; 1-4 July, Queensland University of Technology, Brisbane, 2012.
30. Paretti, M. & McNair, L.. Analyzing the intersections of institutional and dissubject identities in engineering work at the local level, *Engineering Studies*, vol.4, no.1, pp.55-78, 2012. {DOI: 10.1080/19378629.2011.652120}.

31. Pawley A. Universalized narratives. *Journal of Engineering Education*.vol. 98, no.4, pp.309-19, 2009.
32. Pflueger, R., Weissbach, R., & Gallagher, S. Strengthening technical writing knowledge transfer through targeted study in a first-year composition subject. *Proceedings of the Research in Engineering Education Symposium,* Dublin, 2015.
33. Rooney D., Boud D., Reich A., Fitzgerald T., Willey K., Gardner A. Using practice theory to investigate professional engineers' workplace learning. *Proceedings of the IEEE Frontiers in Education Conference* 03-06 October, Seattle, USA, 2012.
34. Ruff, S., & Carter, M.. Characterizing employers' expectations of the communication abilities of new engineering graduates. *Journal on Excellence in College Teaching*, vol.26, no.4, pp.125-147, 2015.
35. Schatzki, T. A Primer on practices. In J. Higgs, R. Barnett, S. Billett, M. Hutchings & F. Trede (Eds.), *Practice-based education*. Rotterdam: Sense Publishers, 2012.
36. Shapiro, Ann, 1991. WAC and Engineering, or Why Engineers Can't Write, *42nd Annual Conference on College Composition and Communication,* Boston, MA, March 21-23, 1991.
37. Skinner I., Mort, P., Calvo, R., Drury, H. & Molina, M.G.. Some do, some don't: student use of online writing resources *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria, 2012.
38. Shove, E., Pantzar, M., & Watson, M.. *The Dynamics of Social Practice: Everyday life and how it changes,* SAGE Publications Ltd, London, 2012.
39. Trevelyan, J., Engineering education requires a better model of engineering practice, *Proceedings of the Research in Engineering Education Symposium*, Palm Cove, Qld, 2009.
40. Trevelyan, J. Mind the gaps: Engineering education and practice, *Proceedings of the 2010 AaEe Conference*, UTS, Sydney NSW, 2010.
41. Walker, M. Engineering Identities. *British Journal of Sociology of Education*, vol. 22, no.1, pp.75-89, 2001. {doi: 10.1080/01425690020030792}.
42. Watt, R. *Concordance.* 2011. Retrieved from http://www.concordancesoftware.co.uk/
43. Wheeler, E., & McDonald, R.L.. Writing in engineering subjects. *Journal of Engineering Education*, vol.89, no.4, pp.481-486, 2000
44. Winsor DA. Engineering writing/writing engineering. *College Composition and Communication*, vol.41, no.1, pp.58-70, 1990.
45. Winsor, D.A. *Writing like an engineer: A rhetorical education.* Mahwah, NJ: Lawrence Erlbaum Associates Inc. 1996
46. Zhu, W. Faculty views on the importance of writing, the nature of academic writing, and teaching and responding to writing in the disciplines. *Journal of Second Language Writing,* vol.13, pp.29–48, 2004.

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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 under-researched 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.*

Partici-pant	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.

Partici-pant*	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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References

Bernstein, B. B. (2000). *Pedagogy, symbolic control, and identity: theory, research, critique*. Lanham Md Rowman & Littlefield.

Bernstein, T. (1971). *Miss Thistlebottom's Hobgoblins*. New York: Farrar, Straus and Giroux.

Carter, M., Ferzli, M., & Wiebe, E. (2007). Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*, *21*, 278.

Colman, B., & Willmot, P. (2016). How soft are 'soft skills' in the engineering profession? *44th SEFI Conference*, Tampere, Finland.

Dym C., Agogino A., Eris O., Frey D., & Leifer L. (2005). Engineering design thinking, teaching and learning. *Journal of Engineering Education*, *94*(1), 103-120.

Engineers Australia. (2013). *Stage 1 competency standard for professional engineers*. Retrieved from https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/130607_stage_1_pe_2013_approved.pdf .

Faulkner, B.E. & Herman, G.L. (2016). Espoused faculty epistemologies for engineering mathematics: Towards defining 'mathematical maturity' for engineering. *ASEE's 123rd Annual Conference and Exposition*, New Orleans, LA.

Fischer, A. (2015). 'Hidden features' and 'overt instruction' in academic literacy practices: A case study in engineering. in T. Lillis, K. Harrington, M.R. Lea & S. Mitchell (Eds.), *Working with academic literacies*. WAC Clearinghouse, Colorado. Retrieved from https://wac.colostate.edu/

Gee, J. P. (1999). Identity as an analytic lens for research in education. *Review of Research in Education*, 25, 99-125.

Geirsdottir, G. (2011). Teachers' conceptions of knowledge structures and pedagogic practices in higher education. In G. Ivinson, B. Davies & J Fitz (Eds.), *Knowledge and identity: Concepts and applications in Bernstein's sociol*ogy (pp. 90-106). Oxon: Routledge.

Godfrey, E. (2009). Exploring the culture of engineering education: The journey. *Australasian Journal of Engineering Education, 15*(1), 1-12.

Godfrey, E., & Parker, L. (2010). Mapping the cultural landscape in engineering education. *Journal of Engineering Education, 99*(1), 5–22.

Goldsmith, R., & Willey, K. (2016). "It's not my job to teach writing": Activity theory analysis of [invisible] writing practices in the engineering curriculum. *Journal of Academic Language & Learning, 10*(1), A118-A129

Goldsmith, R., & Willey, K. (2015). Activity theory analysis of the visibility of writing practices in the engineering curriculum. *Proceedings of the 6th Research in Engineering Education Symposium*, Dublin, Ireland.

Goldsmith, R., Willey, K. & Boud, D. (2012). How can writing develop students' deep approaches to learning in the engineering curriculum? *Proceedings of the 2012 AAEE Conference*, Melbourne, Victoria.

Goldsmith, R., Reidsema, C., Beck, H., & Campbell, D.A. (2010). Perspectives on teaching and learning in engineering design across four universities. *ConnectED 2010 – 2nd International Conference on Design Education*, UNSW Sydney.

Hacker, S. (1989). *Pleasure, power and technology: Some tales of gender, engineering, and the cooperative workplace*. Winchester Massachusetts: Unwin Hyman Inc.

Herrington, A.J. (1985). Writing in academic settings: A study of the contexts for writing in two college chemical engineering courses. *Research in the Teaching of English*, *19*(4), 331-361.

Hilgers, T.L., Hussey, E., & Stitt-Bergh, M. (1999). "As you're writing, you have these epiphanies": What college students say about writing and learning in their majors. *Written Communication, 16*, 317-353.

Howard, S., & Maton, K. (2011). Theorising knowledge practices: a missing piece of the educational technology puzzle. *Research in Learning Technology, 19*(3), 191-206.

Jackson, F. (2016). Unraveling high school English literature pedagogic practices: A legitimation code theory analysis, *Language and Education*, *30*(6), 536-553.

Jenkins, S., Jordan, M.K. & Weiland, P. O. (1993). The role of writing in graduate engineering education: a survey of faculty beliefs and practices, *English for Specific Purposes*, *12*, 51-67.

Johnston, S., & McGregor, H. (2004). Recognising and supporting a scholarship of practice: Soft skills are hard! *Proceedings of the 15th AAEE Conference*, Toowoomba, Australia.

Kemmis, S. & Mutton, R. (2012). Education for sustainability (EfS): practice and practice architectures. *Environmental Education Research*, *18*(2), 187-207.

Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L. (2014). *Changing Practices, Changing Education*. Singapore: Springer.

King, R. (2008). *Engineers for the future: addressing the supply and quality of Australian graduates for the 21st Century*. ALTC. Retrieved from http://www.olt.gov.au

Kranov, A. A. (2009). 'It's not my job to teach them how to write': Facilitating the disciplinary rhetorical socialization of international ESL graduate assistants in the sciences and engineering. *ASEE 2009 Annual Conference & Exposition*, Austin, Texas.

Latour, B., & Woolgar, S. (1986). *Laboratory life: The construction of scientific facts*. Princeton, N.J.: Princeton University Press.

Lee, A. & Taylor, E. (1996). The dilemma of obedience: A feminist perspective on the making of engineers. *Educational Philosophy and Theory, 28*(1), 57-75.

Maton, K. (2000). Recovering pedagogic discourse: A Bernsteinian approach to the sociology of educational knowledge. *Linguistics and Education, 11*(1), 79-88.

Maton, K. (2010). Analysing knowledge claims and practices: Languages of legitimation. in K. Maton & R. Moore (Eds.), *Social Realism, Knowledge and the Sociology of Education: Coalitions of the Mind* (pp. 35-59). London: Continuum International Publishing Group.

Lord, S.M. (2009). Integrating effective 'writing to communicate' experiences in engineering courses: Guidelines and examples. *International Journal of Engineering Education, 25*(1), 196-204.

Mort, P., & Drury, H. (2012). Supporting student academic literacy in the disciplines using genre-based online pedagogy. *Journal of Academic Language and Learning, 6*(3), A1-A15.

Muller, J. (2009). Forms of knowledge and curriculum coherence. *Journal of Education and Work, 22*(3), 205-226. doi: 10.1080/1363908090295790

Nagle, J. (1996). *Handbook for preparing engineering documents*. New York: IEEE Press.

Pawley, A. (2009). Universalized narratives. *Journal of Engineering Education, 98*(4), 309-319.

Pflueger, R., Weissbach, R., & Gallagher, S. (2015). Strengthening technical writing knowledge transfer through targeted study in a first-year composition course. *Proceedings of the Research in Engineering Education Symposium,* Dublin.

Schatzki, T. (2012). A Primer on practices. In J. Higgs, R. Barnett, S. Billett, M. Hutchings & F. Trede (Eds.), *Practice-based education*. Rotterdam: Sense Publishers.

Schon, D. (1983). *The Reflective Practitioner*. USA, Basic Books.

Sheppard, S., Macatanga, K., Colby, A. & Sullivan, W.M. (2009). E*ducating engineers: Designing for the future of the field*. San Francisco: Jossey-Bass.

Staszak, J.-F. (2009). Other/Otherness. in R. Kitchin and N. Thrift N. (Eds.), *International Encyclopaedia of Human Geography, 8,* 43-47. Oxford: Elsevier.

Tonso, K. (2006). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education*, *1*, 273–307.

Trevelyan, J. (2007). Technical coordination in engineering practice. *Journal of Engineering Education, 96*(3), 191-204.

Trevelyan, J. (2009). Engineering education requires a better model of engineering practice. *Proceedings of the Research in Engineering Education Symposium,* Palm Cove, Qld.

Trevelyan, J. (2010). Mind the gaps: Engineering education and practice. *Proceedings of the 2010 AAEE Conference,* UTS, Sydney, NSW.

Wajcman, J. (1992). Reviewed work(s): Pleasure, power and technology: Some tales of gender, engineering, and the cooperative workplace by Sally Hacker; "Doing it the hard way": Investigations of gender and technology by Sally Hacker, Dorothy E. Smith and Susan M. Turner. *Signs, 17*(2), 478-480.

Walker, M. (2001). Engineering Identities. *British Journal of Sociology of Education*, *22*,1, 75-89. doi: 10.1080/01425690020030792.

Watt, R. (2011). *Concordance*. Retrieved from http://www.concordancesoftware.co.uk/

Wheeler, E., & McDonald, R.L. (2000). Writing in engineering courses. *Journal of Engineering Education*, *89*(4), 481-486.

Winberg, C. (2012). 'We're engaged': mechanical engineering and the community. In P. Trowler, V. Bamber, and M. Saunders, (Eds.), *Reconceptualising tribes and territories in higher education: Practices in the 21st century* (pp.142-155). London: Routledge.

Winsor, D.A. (1990). Engineering writing/writing engineering. *College Composition and Communication, 41*(1), 58-70.

Winsor, D.A. (1992). What counts as writing? An argument from engineers' practice. *Journal of Advanced Composition*, *12*(2), 337-347.

Winsor, D.A. (1996). *Writing like an engineer: A rhetorical education*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Winsor, D.A. (2006). Using writing to structure agency: An examination of engineers' practice. *Technical Communication Quarterly*, *15*(4), 411-430. doi:10.1207/s15427625tcq1504_1

Wolff, K., & Hoffman, F. (2014). 'Knowledge and knowers' in engineering assessment. *Critical Studies in Teaching & Learning, 2*(1), 74-95.

Wolff, K., & Luckett, K. (2013). Integrating multidiscipinary engineering knowledge. *Teaching in Higher Education*, *18*(1), 78-92.

WRiSE (2012). Retrieved from http://www.usyd.edu.au/learningcentre/wrise/

Wulf, W.A., & Fisher, G.M.C. (2002). A Makeover for engineering education. *Issues in Science & Technology*, Spring.

Zevallos, Z. (2011). 'What is otherness?' *The Other sociologist*. Retrieved from https://othersociologist.com/otherness-resources/

Zhu, W. (2004). Faculty views on the importance of writing, the nature of academic writing, and teaching and responding to writing in the disciplines. *Journal of Second Language Writing, 13*, 29–48.

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Investigating invisible writing practices in the engineering curriculum using practice architectures

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Investigating invisible writing practices in the engineering curriculum using practice architectures

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ABSTRACT

Writing practices are seen to be essential for professional engineers, yet many engineering students and academics struggle with written communication, despite years of interventions to improve student writing. Much has been written about the importance of getting engineering students to write, but there has been a little investigation of engineering academics' perceptions of writing practices in the curriculum, and the extent to which these practices are visible to their students and to the academics. This paper draws on research from an ongoing study into the invisibility of writing practices in the engineering curriculum using a practice architectures lens. The paper uses examples from the sites of practice of two participants in the study to argue that prevailing practices in engineering education constrain more than enable the development and practice of writing in the engineering curriculum.

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Introduction

Communication, whether written or spoken, is integral to engineering practice and is acknowledged as such both by accrediting bodies such as Engineers Australia (EA), ABET (U.S.) and the Engineering Council (U.K.), and by the engineering faculties that teach engineering. For example, engineering graduates are expected to be able to: 'apply written, oral, and graphical communication in both technical and non-technical environments; … identify and use appropriate technical literature' (ABET 2016); 'communicate information, ideas, problems and solutions to both specialist and non-specialist audiences … be able to evaluate evidence, arguments and assumptions, to reach sound judgements and to communicate them effectively' (Engineering Council UK 2014, 30–31). Given the acknowledged importance of communication, it should be a visible and integral element of the engineering curriculum. In addition, engineering graduates should be entering the workforce with demonstrated competence in written (and spoken) communication. However, this area is consistently reported as being underdeveloped (see e.g. Goldsmith and Willey 2014; Goldsmith and Willey 2015; King 2008; RAE 2007; Sheppard et al. 2009). It is difficult to ascertain the reasons for the lack of visibility of communication practices in engineering curricula, and for the lack of communicative competence of a significant proportion of engineering graduates.

To date, most of the research and initiatives in this area have focused on encouraging engineering students to write: to write more, to write 'better', to write with clarity and to write for particular audiences. This is known as the 'deficit model', which assumes that some students enter the academy with underdeveloped writing abilities, although there is little hard evidence to support this

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assumption. Despite decades of research and some excellent initiatives, both in Australian universities and elsewhere: (see, e.g. Carter, Ferzli, and Wiebe 2007; Fischer 2015; Herrington 1985; Hilgers, Hussey, and Stitt-Bergh 1999; Lord 2009; Mort and Drury 2012; Pflueger, Weissbach, and Gallagher 2015; Wheeler and McDonald 2000), little visible change has occurred, either in terms of the quality of student writing, or in employer perceptions of engineering graduates' written communication. This lack of traction suggests that there are factors that either render writing practices invisible or inhibit the development of them in the engineering curriculum and thus that the deficit may not lie so much with the students as with what occurs within the engineering curriculum. It also indicates a tension in the curriculum: competence in written communication is regarded as an essential graduate attribute by engineering faculties and by international accrediting bodies, yet it is unclear whose responsibility it is to develop such an attribute, nor is it clear who among engineering academics feels confident to do so (Goldsmith and Willey 2016; Kranov 2009).

Both the lack of traction and the uncertainty about whose role it is to develop the graduate attribute of communication highlight the lack of research into the perspectives of writing held by engineering academics. The literature that does exist mainly examines the research writing practices of engineering academics and of their research students (Curry 2014; Koutsantoni 2007; see also Blakeslee 1997) or the writing of practising engineers (Winsor 1990) and of engineering students and novice engineers (Artemeva 2009; Winsor 1996). There are few studies that look at how engineering academics experience writing: how they develop their writing practices, how they view writing in the engineering curriculum, how they view themselves as engineering writing practitioners, how or if they see themselves as modelling writing practices for their students.

The paucity of research in this area prompted a study that investigates engineering academics' perspectives of writing practices in the Australian engineering curriculum. Drawing on examples from this study, we argue in this paper that prevailing practices inhibit engineering academics from seeing the development of writing as part of their role as teachers of engineering.

Missing and invisible writing practices

Writing practices in the engineering curriculum are often either missing or invisible. By invisible we mean that writing practices are fragmented, ad hoc and not seen as developmental. Table 1 provides a snapshot of the main types of writing practices in the engineering curriculum, but is not an exhaustive list. Many types of writing practices are found in the one document, such as a field or lab report that will require notations, equations, freebody diagrams and report writing. Although all the listed writing practices would be essential to engineering practice, the majority of engineering students have opportunities to **practise** only those numbered 1–4 in their curricular studies, as reported in the literature and in previous studies (e.g. Goldsmith, Willey, and Boud 2012). During the course of their studies, students will be assessed on at least seven of the eight text types (reflective writing occurs in some engineering degree programmes but not all), but will have far fewer chances to practise these text types in class, online or for homework, or to receive formative feedback. Where

Table 1. Types of writing practices in the engineering curriculum and examples.

Type	Example
1 Form-filling	Completing a template
2 Drawing and sketching	Freebody diagrams
3 Numerical notation	Noting measurements in lab sessions
4 Formulae and equations	Using formulae to solve problems (in labs or lectures)
5 Short Report writing > 3 pp.	lab reports, computer reports
6 Extended report writing < 3 pp.	Field reports, project reports (group or individual)
7 Reflective writing	Reflective journals, reflective reports
8 Thesis or capstone project	Honours thesis, capstone project (group or individual): typically 20,000–40,000 words

opportunities are provided to practise more extended writing or more complex text types such as types 5–8, they are usually part of a specific intervention (e.g. Fischer 2015; Pflueger, Weissbach, and Gallagher 2015).

The lack of writing practices can be established through examining subject outlines and assessment requirements. For example, an analysis of subjects in first year engineering at two Australian universities shows that there is no writing except for notation required by the students for six of the eight subjects (University A) and for seven of the eight subjects (University B). Up to 90% of the assessment in the subjects is in the form of quizzes, mid-semester tests and final examinations, all of which require calculations, equations and short answer questions (text types 1–4), but not written explanations, justifications or evaluations. 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 (Goldsmith, Willey, and Boud 2012).

There may be excellent writing practices in one engineering subject but these may not be developed in subsequent subjects; thus for students and for staff such practices are invisible. The invisibility of writing practices can be inferred from a number of factors. Firstly, the majority of assessment tasks in engineering subjects focus on producing artefacts based on calculations rather than on reasoned justifications. This is also reflected in the weighting of assessment tasks; a final two- or three-hour examination will usually have a weighting of 60–70% (Goldsmith, Willey, and Boud 2012) but it is not uncommon that a report of several thousand words is given a weighting of 5–10% (Goldsmith and Willey 2016). Secondly, when students are required to write in their engineering subjects it is difficult to see evidence of opportunities for them to practise writing in tutorials or laboratory sessions, in contrast to the emphasis put on practising calculations and doing worked examples of problems. Unlike the development of students' propositional or technical knowledge, writing is mostly not practised formatively, yet it is assessed summatively in the reports that students are asked to produce. Thus writing is often not developed, nor is it seen as an area of knowledge that can or should be developed. Students may then gain an impression of writing as separate from 'doing engineering', a burdensome chore that is required of them by their academic studies and which with any luck will disappear once they become 'real' engineers. This attitude is exemplified in the following comment taken from one of the interviews for this study, where the participant (Charlie, from university A) is talking about students pushing back when they are asked to write a lengthy report: 'The comments I get from them is, "if I wanted to write I would take a degree in Arts"'. (Charlie, University A, interview, this study)

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, or for whom. Engineering students may be unaware of key aspects of writing such as writing for purpose, and writing for diverse stakeholders. Not knowing how to write for different audiences is noted by Braine (1989):

> When [science and technology] students write for their subject teachers who are already fully informed of the subject matter, there is no need to be persuasive or argumentative: masses of data can be regurgitated, often in a rambling and disorganized fashion. Subject teachers may only check for content … .(Braine 1989, 13)

This approach, often known as 'the information dump', is familiar to many engineering academics, and the cause of some dismay. On the other hand, when assessment criteria emphasise reproduction of technical knowledge rather than persuasion or argument, it is understandable that many students will adopt the information dump approach, and will probably not lose marks for doing so.

When students are required to write a report, they may not be aware of the range of report types (or sub-genres) that fall under the broad classification of texts known as reports. They include laboratory reports, progress reports, submissions, research proposals, design proposals, field reports and case study reports (Herrington 1985; Mort and Drury 2012). For each of these, there may be discipline-specific differences, such as the differences between a field report for mining engineering and a field report for chemical engineering. It is often the case that engineering educators have forgotten their own early engineering writing experiences, and so overlook the need to specify what kind of report they are expecting their students to write. In addition, assessment criteria can be ambiguous and feedback from lecturers can be less than constructive; feedforward occurs rarely. 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 subject can be transferred to another circumstance. One outcome of this absence of practice is engineering students who may graduate without the integrated knowledge required for engineering practice, and who may have limited communication capabilities.

This raises a number of questions: why is writing invisible or missing in the engineering curriculum, despite widespread recognition of its importance in engineering practice? Why is it difficult to ensure that writing practices become or remain an integral element of what student engineers learn? What is it within engineering education that does not support the development of writing practices within the curriculum?

Practice theory perspectives

Recent research into education has used practice theory perspectives, which regard practices rather than 'sovereign individuals' (Kemmis et al. 2014) as the primary unit of analysis (Reich et al. 2015, 367). Focusing on the practice allows researchers to consider the interactions of objects, organisations, people, processes, relationships, rules and specific situations when developing an understanding of dynamic practices. Having practice as the unit of analysis acknowledges the situatedness of practices – that they belong to a particular place and time, and unfold in ways that are shaped by specific conditions (Kemmis et al. 2014, 33) or arrangements (Schatzki 2012, 19). Furthermore, 'practices … entwine people, technologies, spaces, time and artifacts' (Rooney et al. 2012), so the analysis of a practice involves developing an understanding of complex interactions of these arrangements.

Kemmis and colleagues (e.g. Kemmis 2013; Kemmis and Mutton 2012; Kemmis et al. 2014) have developed the Schatzkian concept of arrangements further into 'practice architectures', the arrangements that prefigure and shape the conduct of practices. These concepts have evolved into practice architectures theory, or PAT, which can be used as a theoretical and as a methodological resource to understand complex phenomena such as professional learning (Kemmis et al. 2014), curriculum renewal (Goodyear, Casey, and Kirk 2016) or team and project work in engineering practices (Buch and Andersen 2015). 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 norm. In order to disrupt unfruitful practices, or to effect change, it is necessary to understand first how such practices have come about.

Practice architectures comprise 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 the physical environment, financial and temporal resources (e.g. amount of funding for tutors and the number of weeks of a teaching session) 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:

> … in these three dimensions, cultural-discursive, material-economic and social political arrangements do not occur separately from one another; they are always bundled together in practice and in places. Bundled together, they give social life –and our consciousness of it – its apparent solidity, its palpability, its reality and its actuality. (Kemmis et al. 2014, 6).

A site of practice is 'that realm or set of phenomena of which it is a part' (Schatzki in Mahon et al. 2017, 9). 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 academics relate to their students as expert practitioners of engineering writing (social-political arrangements) within their site of practice. Working in concert, these arrangements thus both enable certain teaching and learning practices of writing in engineering, and constrain others. We argue that prevailing practices in the engineering curriculum constrain and enable the development of writing practices. Our approach is outlined in the following section.

Methods

The study

In this paper we use two case studies as examples from a larger study that is investigating the invisibility of writing practices in the engineering curriculum. The study explores what engineering academics say and do about writing practices in the engineering curriculum. We are looking at the practices that are enacted in the context of participants' engineering subjects. The interactions within the subject are the unit of analysis and are termed the site of practice (Mahon et al. 2017, 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. These practices include opportunities for students to practise or develop proficiency in different types of writing, and approaches to assessment of student writing. An examination of the arrangements – the practice architectures – that hold the invisibility of writing practices in the engineering curriculum in place can provide an understanding of how this situation has come about, and suggest ways of making sustainable change. The application of PAT provides a way of revealing 'deeply embedded beliefs and taken-for-granted discourses … that can enable and constrain the practices of … educators' (Salamon et al. 2014, 1).

Engineering academics who coordinate an engineering subject in undergraduate or postgraduate degree programmes in Australian universities were invited to participate in the study; subject coordinators were selected as they have a certain amount of control over the teaching and assessment of their subject. 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 collected. The documents were analysed to identify practices of teaching, learning and assessment, 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. The interviews have been transcribed and analysed to identify emergent themes using Concordance software (Watt 2011) which identifies the frequency of occurrence of words. These themes were then re-analysed to identify elements of practices. Three participants agreed to being observed while teaching; the first author attended their lectures or tutorials and took notes, which were later transcribed. As per ethical requirements, all participants have been de-identified and are referred to by pseudonyms; their institutions are referred to by letters.

PAT analysis of case studies

This section presents a PAT analysis and discussion of case studies of two participants in the light of two prevailing practices that have emerged from our research. The sites of practice are the engineering subjects taught by the participants and the practices that take place within those subjects, including teaching and assessment practices. The two participants have been selected as the analysis of their sites of practice illuminates different practice architectures that influence the development of writing practices in the engineering curriculum. We outline the practice landscape, the 'arrangements necessary for the conduct of a practice' (Hemmings, Kemmis, and Reupert 2013, 475): in this case, the arrangements found in the engineering subject coordinated by each participant. Their sites of practice are then analysed to show how the arrangements (practice architectures) interact with the elements of practice (sayings, doings and relatings) to constrain and enable certain teaching and learning practices of writing in engineering.

The participants

Adam and Damien teach technical subjects in different disciplines; they are from different universities (university A and university B) in Australia and both have been teaching for many years. In addition, both participants have several years' experience working in industry.

The practice landscape for Adam's site of practice

Adam teaches at University A, and has been an engineering academic for several years. Prior to this he worked in industry, and still does consulting work in his field of practice. The engineering subject in this site of practice is offered as a capstone subject for undergraduate students and is also offered as a postgraduate subject. It is delivered in block mode: students attend three intensive two-day sessions over the semester: 'Each teaching period consists of 11.5 hours of mixed lecture and tutorial sessions' (Adam's subject outline 2014, 4) rather than attending weekly classes. The documents for the subject include a subject outline and assignment outlines, which are separate documents. The assessment of the subject comprises three reports, each worth 20% and a final exam worth 40%.

Analysis of Adam's site

One of the six learning outcomes as stated in the subject outline is '**Report writing**: Students learn to structure their reports according to expectations in engineering practice' (Adam subject outline 2014, emphasis in the original).

> Interviewer: I notice that one of the learning outcomes is report writing. How do students learn that?
>
> Adam: All of the assignments are given to me in the form of a report so it's essentially, you're a consultant, give me the answer in the form of a report. (Adam, interview)

Adam's response to this question indicates a gap between the sayings and doings that is a frequently occurring element in his site of practice, both in his explanations and in terms of invisibility of explicit instruction about how to go about writing. The students learn to write reports by writing (summatively assessed) reports. While they may be learning by doing, what they are doing is shrouded in assumptions which have not been made clear. The 'expectations in engineering practice' are not made explicit, either in the subject outline, the assignment outlines, or by Adam himself. In reply to the question 'what do you see to be the purposes of writing in your subject?' Adam makes the comment that 'At a deeper level it's an opportunity for students to learn how to write engineering reports'. However, in the documents that outline the assessment tasks (three reports and a final exam), the word 'report' is not used for the first or second assignment; it occurs only in the instructions for the third assignment 'Using results from assignment 2: **determine** design X … Any assumptions needed to develop the design X need to be **discussed** in the assignment **report'** (Adam Assignment 3, 2014, 1, emphasis added). A later interview comment by Adam contradicts the subject outline and the earlier comment:

> I tell them what I want in terms of that [report writing] but I don't really give them an example of one. What I would suggest is it's really a hurdle that – they've got to get over the hurdle without a lot of actual marks being attributed to that component (Adam, interview).

In fact, students are not provided with a model or an exemplar of what is required in the reports, nor are they given information about how the reports are to be structured. Adam does not explain why the hurdle is placed there, nor why there is little assistance provided for the students; nor, for that matter, does he explain why it is a hurdle with not many marks attached to it. Adam's interview response, and his approach to assessing students' writing without practice or models, is an example of the silent narrative of writing in the engineering curriculum – that engineering writing is somehow to be acquired through doing other activities. It also suggests that the development of Adam's own writing practices is invisible to him, and that he has perhaps forgotten what it was like to be a novice report writer.

Adam says that communicating in engineering is a 'fundamental component' of engineering, as illustrated in the following response to the question of what he sees to be the purpose of writing in his subject: 'So it's a little bit of [an opportunity] trying to help them [students] develop communication skills but it's not a key – it's a little bit … Because it's such a fundamental component' (Adam, interview).

When he says 'it's not a key – it's a little bit', he is referring to how the opportunity to develop communication skills is a small part of what the students learn: he identifies the main learning outcome of his subject as follows: 'The learning outcome really is so that they can have a basic – and I mean basic – understanding of the processes, how things fit together and can then use that to solve the problem' (Adam, interview). On the one hand, Adam talks about communication being a fundamental component, but earlier he refers to it being a 'hurdle'. It may well be a fundamental hurdle. Or it may be an example of how we are not always consistent in what we say.

The mode of delivery of a subject, in addition to how it is taught, has a major impact on how and what students learn. Keeping in mind 'the view that agent, activity, and the world mutually constitute each other' (Lave and Wenger 1991, 33) it can be argued that the context in which the learning takes place is critical. The block mode in which Adam's subject is taught (the material-economic arrangements) enables certain kinds of teaching and learning practices while constraining others.

The observation of one of the block sessions provided the following information. It was a revision session before the final exam. The session was held in a tutorial room, but Adam adopted mainly a lecturing style and took a knowledge transmission approach to his teaching rather than a learning facilitation approach (Kember and Kwan 2000; Samuelowicz and Bain 2000). He talked at length and had Powerpoint slides with dense information. The students sat silently. Every few minutes Adam would ask questions of the group of students; the questions were seeking to test students' propositional (or technical) knowledge. The students were visibly uncomfortable with this and either did not venture an answer or whispered it. Most of the answers were apparently incorrect. Students were not asked to discuss the information in pairs or small groups, although they were sitting at tables where discussion and collaboration would have been quite easy. In response to the question: 'what opportunities are there for students to practise their writing in your subjects?' Adam replies: 'Very little, other than the assignments', but incidental writing practice could have been built into the session; for example, asking the students to write down their response to a question and comparing answers with a fellow student before giving their answer to the whole group. Adam is not alone in this; many engineering educators do not use opportunities in their lectures and tutorials for students to practise such incidental kinds of writing. It is not known whether it is because they do not see it as a useful way of learning, or whether anything that is written needs to be assessed, so marking 'extra' writing would put an unbearable burden on their teaching.

Viewing the elements of Adam's practice through the lens of PAT illuminates the tensions within his practices. While Adam provides opportunities for his students to write (reports) in his subjects, there is no provision for practising report writing without being assessed. Adam says, and probably thinks, he is providing practice in report writing. He is certainly giving his students the opportunity to develop their report writing, but practising strongly implies learning to do something, and having the opportunity to fail, without penalty. Thus we can see that Adam's sayings do not align with the doings and relatings in his site of practice. As noted, Adam acknowledges that there are few chances for the students to practise writing except when writing the assignments:

Very little, other than the assignments. They may choose to - you know, in answering those assignments they may choose to have a few drafts but there's no real time where they've got an hour spare to sit down and do something. It's one of the failings. (Adam, interview)

Adam makes the comment that 'It's one of the failings', but it is not clear what the failing refers to: whether it is a failing of the block mode in which the subject is delivered, or of the subject coordinator not to provide the opportunity for students to write a draft or a failing of the students that they do not take the time to write a draft.

The assessment tasks that the students are required to do and how these tasks are weighted are examples of the material-economic arrangements and doings of Adam's site. As already noted, students are required to write three reports, each worth 20%. There was no information in the subject outline, in the separate assignment outlines or in the lecture slides about assessment criteria, length of the report or allocation of marks for any aspect of the assignments. It is unknown whether students asked about this in the face-to-face sessions or on the LMS for the subject. When asked about assessing writing, Adam was quite clear about what he was looking for:

Interviewer: How do you assess their writing and can you describe the qualities that you're looking for in their reports?

Adam: Clear, precise, concise. I'm looking for well-structured arguments. They've got to be able to justify what they're doing. If they can't justify what they're doing, they won't get the marks for the subject. (Adam, interview)

Adam's comments and approach to assessing the students' reports highlight what has already been referred to; subject coordinators can readily identify what they are looking for when they mark students' written assignments, but they do not always make these expectations clear to the students, and nor do they demonstrate how to do what is required (see also Fischer 2015).

Examples of social-political arrangements include the relationship between the subject coordinator and the students, the relative importance of writing practices to propositional knowledge, and how academics relate in the faculty. Adam answers the question: 'what assumptions do you make about prior experience or knowledge that they [students] might have in terms of report writing?' with: 'I assume they can write in English which is in many cases a bad assumption' (Adam, interview). While making allowances for a facetious reply, it is still clear that Adam does not have very high expectations of students' writing practices coming into his subjects. However, his recognition does not translate into providing practice in writing, nor in modelling writing practices himself. This suggests a lack of agency about developing the writing practices of his students. It is not clear whether he thinks it is not his job, or whether it is too hard a job, but there are opportunities to develop student writing within his site of practice that he chooses not to take up.

When asked if he could see writing being developed sequentially, Adam answered: 'In the subjects, I don't see the writing being developed. Across different subjects, the limited involvement I have over multiple years – if anything, I think it gets worse' (Adam).The following question asked whether his view reflected the faculty view: the response was ' … I would say other faculty in the hierarchy aren't concerned that way because if they were, we would be employing academics who can speak and write English' (Adam).

Adam's isolation from the faculty is demonstrated both by his comments about other faculty members and by the lack of connection between the learning in Adam's subject and what precedes and follows it. The subject description in the subject outline focuses on what will be learned in that subject; the only mention of other subjects is the following: 'Students will apply the theoretical knowledge developed in undergraduate or earlier subjects' (Adam subject outline 2014, 2). If individual subject coordinators focus only on what is taught in their subjects, they may well lose sight of what and how students are learning throughout their degree programmes.

The practice landscape for Damien's site of practice

Damien teaches at University B and similarly to Adam, has been an engineering academic for some years, with prior experience in industry. He has held senior positions in the school of engineering in which he teaches. This school belongs to a discipline of engineering that has a common curriculum shared by several Australian universities for years 3 and 4 of the Bachelor degree. The subjects that Damien teaches feed into the common curriculum. The documents for this site include the subject outline, assignment outlines which detail the requirements of the assignments, and a report-writing guide (RWG), to which Damien has made significant contributions. The RWG, used by all the universities sharing the common curriculum, is a substantial document which provides extensive information about the field-specific requirements of engineering reports in terms of content, format, language and presentation. The assessment tasks for this subject are 2 numerical reports worth 20% and 5%, two field reports worth 15% and 30% each and a final examination worth 30% (Damien subject outline 2014, 7). The first field report is preliminary, to provide students with formative feedback. The second report is based on the first one.

Analysis of Damien's site

One of the four learning outcomes of Damien's subject states:

> students are expected to be able to … **prepare** [emphasis added] a technical report that presents the results of a study on a [X] project that is consistent with the requirements and standards of the School of [X] Engineering and relevant professional society. (Damien's subject outline 2014, 3)

This outcome is supported by resources such as the RWG, which is included in the list of references in the subject outline, and an introductory lecture given by Damien:

> … we provide them [the students] with a copy of the report guideline and I give a lecture on why it's important and what are the elements they need to be aware of when they're writing reports. So right from the day one when they enter university we provide them with this. (Damien, interview)

It can be seen that the cultural-discursive arrangements and the sayings interact to enable report-writing practices in Damien's site of practice (and other subjects in his school); the subject outline includes assessment criteria for the assignments which specifically mention 'Interpretation of information and calculations' and 'Discussion and demonstration of further research' (Damien subject outline 2014, 9). Damien also comments on the development of students' writing practices within the school of X engineering, in response to the question: 'How do your students learn or acquire engineering writing practices?' he replies: 'There is the report writing guide and then there is the practice in terms of writing reports throughout the – in the different courses throughout the years' (Damien, interview).

On the other hand, writing practices are narrowly defined; he refers to writing (in the interview and in the subject outline) only in the context of report-writing skills. This seems to indicate that for him the writing is firmly located in the domain of (engineering) reports; there is no broader interpretation of other kinds of writing student engineers might do. The subject outline uses the wording 'prepare a technical report' rather than 'write a technical report', in line with the wording used by EA in its descriptors of the professional competency of communication (Engineers Australia 2013, 6). This may be an example of the broader cultural-discursive arrangements of the prevailing narrative of engineering that distances writing from what engineers do, so that even within a site where writing practices are explicitly developed there seems to be an inclination not to name writing as an activity or a practice.

Most of the assessment items in Damien's subject require students to write reports. Report writing is practised and scaffolded in Damien's subject and is developed through the major in which his subject is situated. Students receive explicit information about what is required in the writing of the report (with exemplars in the guide) and formative feedback. They also have the opportunity to practise their writing, both with the preliminary report: 'The idea of the preliminary report is for the students to have two turns at writing the report' (Damien) and through an open-access online report-writing site with self-paced activities which features an engineering field report (Learning

Centre University of Sydney 2012). The preliminary field report is given formative feedback, which can then be used for the second report. Damien introduced the scaffolding of the report because an Academic Language and Learning lecturer at his university suggested it. Thus it can be seen that the material-economic arrangements and the doings of Damien's site of practice enable students to practise and develop their report-writing practices.

As noted, Damien has had senior roles in the school's hierarchy, and this might explain some of the influence he has over the school curriculum beyond the boundaries of his subject (the social-political arrangements of his site of practice). Damien has strong connections with the school in which he is situated: he refers to committees of which he is a member, he knows what the practices of writing are in his school, and has had significant input into developing students' report-writing practices in the subjects that are taught in his school. He demonstrates agency in developing and sustaining students' writing practices within his school, as revealed in his sayings, doings and relatings. However, Damien has limited knowledge about other schools in his faculty and so is not prepared to comment on their practices: Interviewer: 'So you can't comment on what happens in the rest of the faculty?' Damien: 'I'm not too sure what happens in the rest' (Damien, interview).

He makes the comment several times: 'I can't talk about the faculty at all. I can only talk at the school level' (Damien, interview). As long as students stay within Damien's school, they will practise and develop the report-writing practices of that school; Damien refers to the 'cycle' of report writing that the students experience as they progress through their degree, and outlines the writing workshops that he runs for fourth year students who are doing their honours thesis, as the following comment illustrates:

> So they're constantly practising these skills because they're not going to write - after one cycle they're not going to necessarily be able to write a good report the second time round. It takes a lot of feedback – and feedback's important for students – for the students to understand their weaknesses and where they can improve in the future. Even introducing the first year, by the time they get to the fourth year it doesn't necessarily mean they can write good reports (Damien, interview).

Damien's site of practice provides strong 'working conditions' (Goodyear, Casey, and Kirk 2016) for students to learn to write reports in the context of the field of knowledge (X engineering). It can be seen in this analysis that the cultural-discursive arrangements interact with the material-economic and social-political arrangements, and with the elements of practices (sayings, doings and relatings) to enable the practice and development of students' learning of writing engineering reports. However, the range of writing skills is defined only as report writing, so graduates from this school may be well equipped to write (X) engineering reports, but their proficiency in other types of writing used in engineering practice could be less developed.

Discussion

The PAT analysis of the two sites of practice presented in this paper reveals prevailing practices in the development and practice of writing in the engineering curriculum.

Prevailing practice 1: writing as an unsustained practice in the engineering curriculum

For a practice such as writing to be sustained, it needs to be developed and practised within and across engineering subjects so that students can see it as part of what they are learning to do, just as the ability to use formulas, equations and problems is practised and developed. As noted earlier, writing in engineering subjects is often not viewed by staff or by students as a developmental practice. While students' propositional knowledge is intentionally scaffolded throughout their engineering degree, it is entirely possible that their writing remains at the same level as when they entered; in some cases, if students are not expected to write extensively for many of their assessment tasks, their writing may even deteriorate. Adam's site of practice illustrates the isolation of his subject from others in the engineering major in which he teaches and the lack of opportunities for practising writing, or for receiving formative feedback, for the students enrolled in his subject.

There are many ways to practise and develop students' writing within their engineering subjects without adding to an already crowded syllabus. Students could be writing to facilitate their command of the language of their discipline; to clarify their thinking; to develop their ability to communicate complex and often technical concepts to different audiences; to share ideas; to explain to fellow students; to develop their critical thinking; to solve problems and to justify their reasoning. However, these opportunities are infrequently provided within subjects or across sequences of subjects. As has already been noted it is often difficult to see where writing is developed throughout an engineering degree programme, as engineering subject coordinators are not informed, or do not inform themselves, of how writing is being developed in preceding and subsequent subjects in the programmes in which they teach. This suggests a siloed environment within the faculty and might explain in part the invisibility of writing practices in the curriculum.

On a more positive note, Damien's site of practice gives an example of where writing is developed, both within his subject and the subjects that follow. It shows how practice architectures can enable the development of writing practices when all the arrangements support this, and when the agency of the practitioner enables the practices to take place.

Prevailing Practice 2 learning to produce an artefact rather than learning the process of writing

Writing is often separated from learning by engineering students and engineering academics. As discussed earlier, the disaggregation of writing from 'doing engineering' can cause students to regard writing as a (possibly) necessary evil that is part of their academic studies but which has no bearing on what they will do as professional engineers. One of the consequences of this view (which may be shared by their lecturers) is the 'production' of reports to fulfil assessment requirements, where the quality of writing is not highly valued. This is demonstrated by how the writing is weighted in the assessment criteria, by the weighting of assignments compared to final exams (see e.g. Goldsmith, Willey, and Boud 2012) and by student responses to the weightings. As Boud points out: 'Students are not simply responding to the given subject – they carry with them the totality of their experiences of learning and being assessed and this certainly extends far beyond concurrent and immediately preceding subjects' (Boud 1995, 36). Research has shown that students are being asked in subject after subject to write often quite lengthy reports, requiring many hours of work, which are worth considerably less than a final exam. It is not surprising if the cumulative effect is students devaluing writing as an activity and as a form of assessment. Another outcome is that many engineering students and graduates have had limited practice in writing in a narrow range of text types or genres and may not be able to transfer their writing skills to the broader range of writing required in engineering practice and research.

Despite Adam's sayings, the arrangements and practices in his site of practice constrain the learning of writing practices; students are neither provided with practice in writing and nor is there provision of exemplars of written tasks. It could be surmised that the practice architectures currently in place in Adam's school and faculty constrain the visibility of development of writing practices. There is no mention, demonstration or visible relationship of levels of complexity of writing practices, or of a range of writing types. In Damien's site of practice, the practice architectures enable writing practices that are developed and supported in a field-specific context and throughout a degree programme. However, the students practise writing in a narrow range of genres, and learn writing practices for their exchange value rather than for their use value (Williams 2012). Damien sees writing skills as providing a competitive edge in industry, rather than as a way of learning, as shown in the following comment about graduates with poor writing skills: ' … those who had difficulty in putting a report together, it reflected badly on their performance in the organisation and put them behind in terms of the standing with the others. Because it's basically a competition' (Damien, interview).

For him, writing is primarily a way of enhancing students' competitiveness in the workplace. The project of Damien's site of practice is to produce graduates with a competitive edge because of their enhanced report-writing skills, not necessarily to produce graduates who can write to argue, question, justify or challenge. The analysis of these two sites, from different universities and different fields of engineering, highlights amongst other things how good practice may exist in one school (and sometimes just in one subject) but may be unknown and therefore invisible in another school. It also indicates disconnections between the subject coordinators and the engineering faculty in which they work. Adam seems quite isolated from the rest of his faculty, and although Damien has a strong connection with his school, he is unaware of, and possibly not interested in, the practices in the engineering faculty to which his school belongs.

These prevailing practices could go some way towards explaining the lack of visibility of writing practices in the engineering curriculum: if engineering academics are unclear or uncertain about the purposes of writing in their subjects, this lack of clarity is likely to impact how writing practices are enacted in their subjects. It may also be conveyed to their students. As previously noted, when engineering educators focus only on the knowledge taught in their subjects, they are often not aware of what students are learning overall. This would also militate against subject coordinators seeing that students' writing practices are developmental; if a teacher is not aware of the type and level of writing that students have attained prior to enrolling in that subject, it is very possible that students may be asked to write at the same or a lower level, rather than building on their skills and knowledge.

Conclusion

As engineering practice becomes more complex, and there are increasing demands for engineering graduates to be 'professionally ready' when they enter the workplace, competence in written communication will become more important as a graduate attribute. Yet, as has shown by the practice architectures analysis of the case studies in this paper, current prevailing practices can constrain the development of engineering students' writing practices throughout the engineering curriculum. Where writing practices are enabled, it is within a narrow frame of report-writing skills for a particular field. The PAT analysis shows how arrangements interact to support prevailing practices in the two sites. While this analysis is only on two sites of practice, the lens of PAT can provide opportunities for engineering educators to discuss how changes in prevailing practices might come about. In the words of Kemmis and colleagues: 'we cannot transform practices without transforming existing arrangements in the intersubjective spaces that support practices' (Kemmis et al. 2014, 6, italics in the original). As previously noted, it is necessary to identify what the current practices are in order to bring about desired transformations. The perspective provided by PAT can allow investigators to reveal the 'deeply embedded beliefs' (Salamon et al. 2014, 1) and encourage ways of shifting the practice architectures so that writing practices can be made more visible, and more coherently developed, within the engineering curriculum.

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References

ABET. 2016. *Criteria for Accrediting Engineering Programs*. Baltimore: ABET. http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2016-2017/.

Artemeva, N. 2009. "Stories of Becoming: A Study of Novice Engineers Learning Genres of their Profession." In *Genre in a Changing World*, edited by C. Bazerman, A. Bonini, and D. Figueiredo. Colorado: The WAC Clearinghouse. https://wac.colostate.edu/books/genre/chapter8.pdf.

Blakeslee, A. M. 1997. "Activity, Context, Interaction, and Authority." *Journal of Business and Technical Communication* 11 (2): 125–169.

Boud, D. 1995. "Assessment and Learning: Contradictory or Complementary?" In *Assessment for Learning in Higher Education*, edited by P. Knight, 35–48. London: Routledge Falmer.

Braine, G. 1989. "Writing in Science and Technology: An Analysis of Assignments from Ten Undergraduate Courses." *English for Specific Purposes* 8: 3–15.

Buch, A., and V. Andersen. 2015. "Team and Project Work in Engineering Practices." *Nordic Journal of Working Life Studies* 5 (3a): 27–46.

Carter, M., M. Ferzli, and E. Wiebe. 2007. "Writing to Learn by Learning to Write in the Disciplines." *Journal of Business and Technical Communication* 21: 278–302.

Curry, M. J. 2014. "Graphics and Invention in Engineers' Writing for Publication." In *Language, Literacy and Learning in STEM Education*, edited by M. J. Curry, and D. I. Hanauer, 87–106. Amsterdam: John Benjamins.

Engineering Council UK. 2014. *The Accreditation of Higher Degree Programs, 3rd Edition*. http://www.engc.org.uk/engcdocuments/internet/Website/Accreditation%20of%20Higher%20Education%20Programmes%20third%20edition%20%281%29.pdf.

Engineers Australia. 2013. *Stage 1 Competency Standard for Professional Engineers*. https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/130607_stage_1_pe_2013_approved.pdf.

Fischer, A. 2015. "'Hidden Features' and 'Overt Instruction' in Academic Literacy Practices: A Case Study in Engineering." In *Working with Academic Literacies*, edited by T. Lillis, K. Harrington, M. R. Lea, and S. Mitchell. Colorado: WAC Clearinghouse. wac.colostate.edu.

Goldsmith, R., and K. Willey. 2014. *Invisible Writing (Practices) in the Engineering Curriculum?* Proceedings of the AAEE2014 Conference Wellington, New Zealand, 8–10 December 2014.

Goldsmith, R., and K. Willey. 2015. *Activity Theory Analysis of the Visibility of Writing Practices in the Engineering Curriculum.* Proceedings of the 6th Research in Engineering Education Symposium, Dublin, Ireland, 13–15 July 2015.

Goldsmith, R., and K. Willey. 2016. "'It's Not My Job to Teach Writing': Activity Theory Analysis of [invisible] Writing Practices in the Engineering Curriculum." *Journal of Academic Language & Learning* 10 (1): A118–A129.

Goldsmith, R., K. Willey, and D. Boud. 2012. *How Can Writing Develop Students' Deep Approaches to Learning in the Engineering Curriculum?* Proceedings of the 2012 AAEE Conference, Melbourne, Victoria, 3–5 December 2012.

Goodyear, V. A., A. Casey, and D. Kirk. 2016. "Practice Architectures and Sustainable Curriculum Renewal." *Journal of Curriculum Studies*. doi:10.1080/00220272.2016.1149223.

Hemmings, B., S. Kemmis, and A. Reupert. 2013. "Practice Architectures of University Inclusive Education Teaching in Australia." *Professional Development in Education* 39 (4): 470–487.

Herrington, A. J. 1985. "Writing in Academic Settings: A Study of the Contexts for Writing in Two College Chemical Engineering Courses." *Research in the Teaching of English* 19 (4): 331–361.

Hilgers, T. L., E. Hussey, and M. Stitt-Bergh. 1999. ""As You're Writing, You Have these Epiphanies": What College Students Say about Writing and Learning in their Majors." *Written Communication* 16: 317–353.

Kember, D., and P. K. Kwan. 2000. "Lecturers' Approaches to Teaching and their Relationship to Conceptions of Good Teaching." *Instructional Science* 28: 469–490.

Kemmis, S. 2013. "The Theories of Practice Architectures and Ecologies of Practices." Accessed 3 August 2016. http://ips.gu.se/digitalAssets/1467/1467159_kemmis-pep-theory-tromso.pdf.

Kemmis, S., and R. Mutton. 2012. "Education for Sustainability (EfS): Practice and Practice Architectures." *Environmental Education Research* 18 (2): 187–207.

Kemmis, S., J. Wilkinson, C. Edwards-Groves, I. Hardy, P. Grootenboer, and L. Bristol. 2014. *Changing Practices, Changing Education*. Singapore: Springer.

King, R. 2008. *Engineers for the Future: Addressing the Supply and Quality of Australian Graduates for the 21st Century*. ALTC. http://www.olt.gov.au.

Koutsantoni, D. 2007. *Developing Academic Literacies: Understanding Disciplinary Communities' Culture and Rhetoric*. Bern, Switzerland: Peter Lang.

Kranov, A. A. 2009. "It's Not My Job to Teach Them How to Write": Facilitating the Disciplinary Rhetorical Socialization of International ESL Graduate Assistants in the Sciences and Engineering. *ASEE 2009 Annual Conference & Exposition*, June 14–17, Austin, Texas. https://peer.asee.org/5093.

Lave, J., and E. Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Learning Centre, University of Sydney. 2012. "WRiSE: Writing Reports in Science and Engineering." http://learningcentre.usyd.edu.au/wrise/.

Lord, S. M. 2009. "Integrating Effective 'Writing to Communicate' Experiences in Engineering Courses: Guidelines and Examples." *International Journal of Engineering Education* 25 (1): 196–204.

Mahon, K., S. Kemmis, S. Francisco, and A. Lloyd. 2017. "Introduction: Practice Theory and the Theory of Practice Architectures." In *Exploring Education and Professional Practice*, edited by K. Mahon, S. Francisco, and S. Kemmis, 1–30. Singapore: Springer.

Mort, P., and H. Drury. 2012. "Supporting Student Academic Literacy in the Disciplines Using Genre-Based Online Pedagogy." *Journal of Academic Language and Learning* 6 (3): A1–A15.

Pflueger, R., R. Weissbach, and S. Gallagher. 2015. *Strengthening Technical Writing Knowledge Transfer Through Targeted Study in a First-Year Composition Course*. Proceedings of the Research in Engineering Education Symposium, Dublin, 13–15 July 2015.

Reich, A., D. Rooney, A. Gardner, K. Willey, D. Boud, and T. Fitzgerald. 2015. "Engineers' Professional Learning: A Practice-Theory Perspective." *European Journal of Engineering Education* 40 (4): 366–379.

Rooney, D., D. Boud, A. Reich, T. Fitzgerald, K. Willey, and A. Gardner. 2012. *Using Practice Theory to Investigate Professional Engineers' Workplace Learning*. In Proceedings: IEEE Frontiers in Education Conference, Seattle, USA, 03–06 October 2012.

Royal Academy of Engineers. 2007. *Educating Engineers for the 21st Century*. London: Royal Academy of Engineers.

Salamon, A., J. Sumsion, F. Press, and L. Harrison. 2014. "Implicit Theories and Naïve Beliefs: Using the Theory of Practice Architectures to Deconstruct the Practices of Early Childhood Educators." *Journal of Early Childhood Research*: 1–13.

Samuelowicz, K., and J. Bain. 2001. "Revisiting Academics' Beliefs about Teaching and Learning." *Higher Education* 41: 299–325.

Schatzki, T. 2012. "A Primer on Practices." In *Practice-Based Education: Perspectives and Strategies*, edited by J. Higgs, R Barnett, S Billett, M Hutchings, and F Trede, 13–26. Rotterdam: Sense Publishers.

Sheppard, S., K. Macatanga, A. Colby, and W. M. Sullivan. 2009. *Educating Engineers- Designing for the Future of the Field*. San Francisco: Jossey-Bass.

Watt, R. 2011. "Concordance." http://www.concordancesoftware.co.uk/.

Wheeler, E., and R. L. McDonald. 2000. "Writing in Engineering Courses." *Journal of Engineering Education* 89: 481–486.

Williams, J. 2012. "Use and Exchange Value in Mathematics Education: Contemporary CHAT Meets Bourdieu's Sociology." *Educational Studies in Mathematics* 80: 57–72.

Winsor, D. A. 1990. "Engineering Writing/Writing Engineering." *College Composition and Communication* 41 (1): 58–70.

Winsor, D. A. 1996. *Writing Like an Engineer: A Rhetorical Education*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

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Using practice architectures to investigate the invisibility of writing practices in the engineering curriculum

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Abstract: Written communication is neither systematically developed nor practised in the engineering curriculum, despite expectations by universities and employers that engineering graduates will be proficient communicators, and despite interventions to develop students' writing. The gap in the development of students' written communication calls for an investigation into the continuing invisibility of writing practices in the engineering curriculum. The lens of practice architectures theory was used to explore how engineering academics view writing in their engineering subjects, and how they develop the writing practices of their students. Practice architectures theory sees practices as shaped by and shaping cultural-discursive, material-economic, and social-political arrangements. A qualitative study examined engineering academics' teaching practices and the extent to which writing is practised and developed within the subjects they teach. Results show the majority of engineering academics in this study view writing as separate from technical engineering knowledge. This impacts the prevailing teaching and assessment practices by not providing opportunities for writing to be practised and developed within the context of engineering education. Unless there is conscious inclusion of writing practices, prevailing teaching and assessment practices will continue to focus on the acquisition of propositional knowledge to the exclusion of the development of writing practices.

Writing practices; engineering writing; engineering curriculum; practice architectures theory

I. INTRODUCTION

A. Background

Despite evidence to the contrary, such as engineers who are highly proficient writers and the demand by employers for engineering graduates with highly developed written communication skills, the perception or belief that engineers do not or cannot write is widely held both within engineering and in the wider community [1-3]. This begs the question of what are the real and potential impacts of this belief. Further, what are the implications for the engineering curriculum, that the ability to communicate in writing - to evaluate, negotiate, critique, justify, challenge, persuade or advise - is not visible? It can mean that writing practices lack value for engineering students and engineering academics, and that the development of writing practices is not enacted, or is enacted in a piecemeal fashion throughout the engineering curriculum.

The lack of visibility of writing practices in the curriculum, with the associated disengagement of the development of writing in the discipline by faculty staff, is evident in engineering faculties throughout Australia and overseas, despite ongoing concerns about gaps in the development of engineering graduate capabilities of written (and spoken) communication, and of the quality of writing of engineers [4-10]. This is also despite the implementation of a wide range of studies, initiatives, strategies and programs to investigate and develop engineering students' writing abilities, dating from at least the 1980s [11-15].

Therefore it is important to explore why this is so: why does such an important aspect of being an engineer and of doing engineering continue to be invisible in the curriculum and in academic practice? The importance of written and spoken communication is clearly demonstrated by its inclusion in engineering faculty graduate attributes and in graduate outcomes by accrediting bodies such as Engineers Australia (EA), ABET (US) and the Engineering Council (UK). Yet the responsibility for the development of this attribute, and the visibility of writing in the engineering curriculum are much less obvious.

One perspective is that the prevailing engineering science-based curriculum in Australia and in the US [16-18] militates against the development of professional attributes such as communication, management and social and environmental responsibility. The engineering science approach valorises convergent thinking [18] and 'emphasizes the scientific and mathematical foundations of engineering, as opposed to empirical design methods based on experience and practice' [19].The academics who teach engineering science subjects often regard themselves as the guardians of the standards of engineering, hence the importance of the 'weeding out' culture which features both in the US and in Australia [16, 20]. 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 working out of equations, multiple choice answers, reproducing correct formulae, rather than group work where students can 'cheat', or written responses that ask for evaluations, judgments, or applying solutions outside of textbook problems. The focus is on technical knowledge, well-structured problems and assessment practices that measure correctness of an answer rather than the process taken to arrive at the right answer. Such an approach tends to result in atomized learning; the more successful students adopt a mode of acquiring knowledge that focuses on passing exams, but they may not see links between

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theory and practice, or the links between one subject and the next.

Another consequence of the engineering science approach to the curriculum is that writing practices tend to be excluded, for any or all of the following reasons. There is no 'room' for writing; there is limited opportunity for writing (with tests, quizzes and final exams), and writing is a different kind of knowledge. 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. According to this view, writing 'belongs' to the disciplines of humanities or social sciences, rather than to the technical disciplines of engineering, science and IT. As reported in a study by [16] on the cultural landscape of engineering education, while most engineering faculty members believed that students should learn '…professional development and communication skills' as part of their preparation to become professional engineers, this information was 'marginalized in Professional Development courses…These courses were referred to by both faculty and students, as "soft" compared to the more technical "hard" courses' [16 p.13].

II. Problem

As noted in the introduction to this paper, writing practices are not part of the dominant narrative of the prevailing engineering curriculum. The prevailing view of engineers (both inside and outside the profession) is of technical problem-solvers [21] rather than as those who pose, frame and challenge the nature and type of problems. This view is reinforced by research conducted by Pawley [22]. Pawley identifies three ways that engineering educators define engineering: engineering as applied science and mathematics; engineering as problem-solving; engineering as making things (22 p.312). It seems that none of these definitions include writing as a way of practising engineering or as a way of learning the practice of engineering; indeed the language of engineering is described as the language of maths (p.313). Engineers use the language of maths to communicate, but this will only allow them to communicate within their discipline, not to people in other disciplines or outside academia (the rest of society). Writing is seen as a different kind of knowledge; it is often ambiguous and interpretive; it means many different things; it is difficult to say when it is right or wrong.

The perspective that there are different kinds of knowledge and different ways of knowing has been explored by a number of researchers, including Bernstein [23]. Bernstein defines two principal educational knowledge codes: a collection code, where knowledge is hierarchical and builds on what has gone before, and an integrated code where knowledge is segmented and relies on the insight or 'gaze' of the knower [23]. Engineering is classified by several authors [24-27] as a knowledge code, with a hierarchical knowledge structure [25]. There is less literature that classifies writing or writing practices as a type of knowledge, but Macken-Horarik claims that secondary school English is predominantly a knower code [28]. Perhaps part of the resistance of engineering education to writing is to keep engineering 'pure' and 'hard', and avoiding association with something as 'soft' as writing practices – writing seen as a 'soft' skill and being seen to be part of a 'soft' (humanities) discipline.

Engineering defines itself as a field that produces useful objects and resists seeing textual mediation as part of what engineering is [18, 29]. This meshes with the belief that the engineering science paradigm represents what engineering is in practice [22, 30]. Along with the engineering science paradigm is the focus on engineers as solving technical problems by themselves, as reported by [10].These elements comprise what are known in practice architectures theory (outlined in the following section) as the cultural-discursive arrangements of the meta-practices of the engineering curriculum which constrain writing practices as being thought of as part of engineering studies, by enabling the belief that engineering **is** mathematics and has no need for textual realisation beyond the language of mathematics.

III. Methodology & Methods

Recent research into education has used practice theory perspectives, which regard practices rather than individuals as the primary unit of analysis [31]. Focusing on the practice allows researchers to consider the interactions of objects, organisations, people, processes, relationships, rules and specific situations when developing an understanding of dynamic practices. Having practice as the unit of analysis acknowledges the situatedness of practices – that they belong to a particular place and time, and unfold in ways that are shaped by specific conditions [32, p.33] or arrangements [33, p.19]. Practice architectures theory [34] has evolved from Schatzki's practice theory [33], 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 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 [32]. 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 academics relate to their students as expert 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.

In this paper we use examples from a study that is investigating the invisibility of writing practices in the engineering curriculum. The study explores what engineering academics say and do about writing practices in the engineering curriculum. We are looking at the sites of practice of each of the participants to identify the practice architectures that prefigure the teaching and learning practices, such as the wordings in subject outlines and assessment documents, assessment tasks and weightings, time allocated to writing practices in class, and the relative importance placed on developing writing practices by the subject coordinators in their engineering subjects. We also look at the practices that are enacted in the context of participants' engineering subjects. The practices are 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. These practices include opportunities for students to practise or develop proficiency in different types of writing, and approaches to assessment of student writing. An examination of the arrangements – the practice architectures – that hold the invisibility of writing practices in the engineering curriculum in place can provide an understanding of how this situation has come about, and suggest ways of making sustainable change.

The study comprises analyses of the sites of practices of nine engineering academics from five different engineering faculties in Australian universities. 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 selected as they have a certain amount of control over the teaching and assessment of their subject. 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 collected. The documents were analysed to identify practices of teaching, learning and assessment, 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 agreed to being observed while teaching; the first author attended their lectures or tutorials and took notes, which were later transcribed. The interviews have been transcribed and analysed to identify emergent themes using Concordance [35]. These themes were then re-analysed against the documents and classroom observations to identify practice architectures and elements of practices. As per ethical requirements, all participants have been de-identified and are referred to by pseudonyms; their institutions are referred to by letters.

IV. RESULTS AND DISCUSSION

Results reveal that the majority of engineering academics in this study view writing as separate from technical engineering knowledge. Further, the prevailing teaching and assessment practices constrain the learning of writing practices by not providing opportunities for writing to be practised and developed within the context of engineering education. There are examples of practices that enable writing to be developed, but they are isolated and not supported throughout the engineering curriculum.

A. Prevailing Practice: writing practices as separate from engineering technical knowledge

Writing is a different type of knowledge from engineering science (and related types of knowledge in the STEM domain). The evidence for this claim can be found in: cultural-discursive arrangements and sayings that separate writing practices from other types of learning, or that do not refer to writing practices in descriptions of what engineers do; material-economic arrangements and doings that do not include assessment criteria for writing within written assessment tasks, or that outsource the development of writing practices to academic literacy specialists (often outside the engineering faculty), or that see writing as competing for scarce resources (teaching time in class; time needed to mark writing); social-political arrangements and relatings that regard the development of writing practices as someone else's responsibility.

B. Examples from case studies

Felicity's site of practice is a third year subject in the electrical engineering discipline in University C, with a cohort of approximately 110 students. In her interview, Felicity was enthusiastic both about the subjects that she taught and her teaching. She welcomed the opportunity to be interviewed about what went on in her site of practice, although it was difficult to get her to answer questions about writing practices because she would reply by explaining what the students needed to do to demonstrate their technical knowledge.

There are five learning outcomes in the subject outline: 'On completion of this unit [students] should be able to…calculate and analyse loadflow and faults… Calculate power flow… Identify fundamentals… Explain principles… Select a suitable dc and ac motor…' (Felicity subject outline 2014 pp.2-3). The emphasis is very much on the acquisition of propositional knowledge, but two learning outcomes are worded as though they would require more than notation:

3. Identify fundamentals of power system economics, generation costs, tariffs, market rules and performance

4. Explain principles of single and three phase transformers operation and performance (winding, testing, losses and efficiency) (Felicity subject outline 2014 pp.2-3).

Yet there is no mention in the subject outline, nor in the interview, nor in the assessment documents, of any opportunity to practise this kind of writing. The writing of numbers (equations, formulae and calculations) is present, but this is not seen as writing by the participant and may not be seen as writing by students. The assessment tasks are reports but the emphasis is on accuracy of calculations and solutions, although Felicity comments that students need to evaluate which is the optimum design:

…see you need to consider this as some sort of product that you are going to develop; that you are going to manufacture. You want to sell it. How do you provide information to make others convinced to buy such a product? (Felicity interview)

There are no criteria that ask students to provide this information, or that assess the evaluations that the students make. The report is more like completing a template than writing a report from scratch: ‘There is a booklet that - they need to fill that booklet, answer all those questions’ (Felicity interview). The report format seems to be in a loose bundle of papers and there is no mention of report structure: ‘There is some sort of booklet, but in terms of report they need to provide some sort of thing like that. Yeah, loose bundle again’ (Felicity interview).

The practices of writing an explanation, justification or evaluation are absent; the ‘reports’ in this subject appear to be sets of calculations and completed tables of information (no exemplar student reports were provided). There are also (as in all sites of practices) oral explanations given to the students (sayings) that are not evidenced in the documentation: ‘Also, we try to explain - prior to each session we try to explain what we are expecting from these questions. For instance do they need to answer - just give a brief answer’ (Felicity, interview). So each semester the same explanations are given, or similar, or different, depending on who is doing the explaining, and who is hearing the explanations. These cultural-discursive and material-economic arrangements interact to suggest the ephemeral nature of writing practices in this site of practice, and also pose the question of why this information is not included in the subject outline. The absence of this information about the writing practices in Felicity’s subject could indicate an absence of writing practices or an ‘absence’ in Felicity’s perceptions about what students should be learning and doing in her site of practice. The same practice occurs in the sites of other participants: what they tell the students is not what is written in the assignment description (Adam, Eric, Garth, Ivan). This cultural-discursive arrangement, this explicit documentation, can be part of a site of practice (in four sites it is present) but is often missing. Yet the descriptions of propositional knowledge assignment outlines are noticeably present and consistent across sites of practices, and appear to include all the relevant information that students need to complete the assignments successfully.

These practices consolidate the cultural-discursive arrangements and social-political arrangements that can be detected in many engineering subjects where writing or communication skills are seen as separate from technical knowledge, and not the responsibility of the subject coordinator to develop. In Felicity’s site of practice, she does not need to show the students how to write a report because that is covered by another subject that students do which prepares them for report writing, presumably of all kinds of reports. Felicity does not know the name of the subject that the students do, nor the content of the subject, nor whether it is just for electrical engineering students or for all engineering students, or for all students in the faculty, which includes science and IT students. It can be seen from Felicity’s comment below that she does not see her role as developing students’ writing practices for engineering practice unless and until the students are doing a capstone or thesis:

Interviewer: How do you - the writing practices in your subject prepare the students for the writing practices of engineering?

Felicity: For this unit [course] they do not need to write too much. So we don't deal with this case…

Interviewer: How do your students learn or acquire those engineering writing practices?

Felicity: I think there is a - for final year project they will learn how to do so. (Felicity interview).

A comment from another participant, Garth illustrates the emphasis he places on practicing propositional knowledge in tutorials in his site of practice (a technical subject in civil engineering):

Garth: So we have too many things that we want to teach and we only have 13 weeks. So we actually use tutorial times…to teach something, do a practice. So I thought that is the best way to utilize the time but by doing that there's no practice actually for a student to improve their writing skill (Garth University C, interview).

This comment highlights two elements of practice that occur within five of the sites of practice being analyzed: how the focus on propositional knowledge squeezes out the development of writing practices, and how writing practices are seen as competing for time with the teaching of propositional knowledge. Six participants make comments that indicate they see writing as either/or: either they spend time in class practicing technical problems related to the content of their subject, or they spend time in class practicing writing, presumably without any content. Three participants in this study saw that writing practices could be used to develop students’ understanding of their technical knowledge by asking them to evaluate, explain, justify or recommend particular methods, theories, or solutions. Furthermore, what is not said is also part of the cultural-discursive arrangements: if writing/communication is not listed as a subject or task learning outcome, it has no presence for the students. When this effect is multiplied over the majority of engineering subjects, the impact is strong and clear: engineering is about technical knowledge, and has little to do with communication.

C. *Prevailing Practice: writing practices not practised or developed in the context of the engineering curriculum*

The evidence for this claim is found in: cultural-discursive arrangements and sayings that see writing practices as not needing to be developed in the context of the subject being taught; material-economic arrangements and doings that assess writing (reports) without providing an exemplar or opportunities for formative feedback; social-political arrangements and relatings that relegate written communication to the lowest level of importance or that allocate insignificant assessment weightings to the quality of writing.

Table 1 summarizes the assessable writing tasks of all the participants, indicating the weighting of each task and whether students have opportunities to submit drafts and/or to receive formative feedback before being summatively assessed. As can be seen, six sites of practice provide no formal opportunities for submitting drafts or receiving feedback. The three participants who do provide opportunities for feedback have structured the writing tasks so that students are required to submit reports for peer review (Charlie) or for tutor feedback (Charlie, Damien, Harry). The range of weighted marks allocated to the writing tasks are shown, as well as the percentage of marks allocated for quality of writing in the assignments. Four sites of practice either do not include information about how or if writing quality is evaluated, or apparently allocate zero marks for it, while one site allocates 5% for correct spelling, grammar and neatness (Garth's site). All the sites of practice teach technical subjects with the exception of Charlie's site, which is a post-internship review subject.

D. *Practices that enable the development of writing practices in the engineering curriculum*

In contrast to Ivan's site of practice, the practice architectures of Damien's and Harry's sites of practice enable the development of writing practices by integrating propositional knowledge with writing practices through the emphasis (the social-political arrangements) on writing assignments and by providing formative assessment (the material-economic arrangements) on preliminary reports or drafts (see Table 1). The cultural-discursive arrangements and sayings of Damien's and Harry's sites of practice support the development of writing practices in the context of learning the propositional knowledge of the subject; the subject outlines and assessment task descriptions include specific explanations of approaches to the writing tasks and how to format the reports. Harry makes the point in the following comment that students start learning when they start doing, and that writing the lab reports encourages students to engage with the learning:

Harry: So we're asking them to look at what they've got, see how that relates to the theory and analyse things and tell us what they think about it in a fairly structured way. That's where they start actually learning the things. That's why we ask them to write reports, so they actually engage with it (Harry interview).

These practices demonstrate that the development of writing practices need not constrain the teaching of propositional knowledge, and that the development of one kind of knowledge can interact to enhance the understanding of other kinds of knowledge, as has also been shown in studies of student learning and writing in engineering courses [8, 11-14].

VI. CONCLUSION

Overall, the prevailing practices of the engineering curriculum tend to constrain the development of writing practices by positioning propositional knowledge as separate from the ability to write an evaluation or justification of this knowledge. The separation of these two types of knowledge also reveals the practice architectures of the engineering curriculum which interact to place propositional knowledge as of higher value than professional attributes, rather than enabling practices that integrate these attributes with the technical knowledge needed to become an engineer. The lens of practice architectures theory has provided a way of considering the engineering curriculum to see the interconnectedness of arrangements that keep certain practices in place, and which constrain the development of others. If writing practices are to be made more visible within the engineering curriculum, there will need to be shifts in how writing is thought of, spoken of, enacted and valued so that it is seen as integral rather than extraneous to engineering education and practice.

TABLE I. WRITTEN ASSESSMENT TASKS ALL PARTICIPANTS

participant	university	Written assessment tasks & weighting	% of marks assigned to writing quality	Practised or formatively assessed
Adam	A	3 reports worth 60% of total assessment	Not specified	No
Bernice	A	2 reports worth 40% of total assessment	25%	No
Charlie	A	1 reflective report worth 55% of total assessment	25%	Yes
Damien	B	Scaffolded writing tasks; 4 reports worth 70% of total assessment	25%	Yes
Eric	A	3 group projects worth 65% total mark: 1st project is basis of 2nd project which is basis of 3rd project	0%	No
Felicity	C	Problem solving task 40% (group + individual component)	0%	No
Garth	C	2* group projects worth 40% of total assessment	5%	No
Harry	D	3 lab reports: 2 formative, 1 summative 20%	25%	Yes
Ivan	E	1 computer report 9%, 1 lab report 10%	Not specified	No

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REFERENCES

[1] Beer, D.F., "Reflections on Why Engineering Students don't like to write -and what we can do about it", Professional Communication Conference, 2002. IPCC 2002. Proceedings. IEEE International. Portland, OR, USA.

[2] Breed, G., "So you think that engineers don't (or can't) write", Editorial, High Frequency Electronics 2010, vol. 9 no.5, May.

[3] Shapiro, Ann, "WAC and Engineering, or Why Engineers Can't Write", 42nd Annual Conference on College Composition and Communication, Boston, MA, March 21-23,1991. http://files.eric.ed.gov/fulltext/ED332199.pdf

[4] Appleby, Roberts, Barnes, Qualter& Tariq, "Who wants to be able to do references properly and be unemployed? STEM student writing and

employer needs", Journal of Learning Development in Higher Education Special Edition, November 2012.

[5] King, R., Engineers for the Future: addressing the supply and quality of Australian graduates for the 21st Century, ALTC, http://www.olt.gov.au, 2008.

[6] Male, S.A., Bush, M.B., Chapman, E.S., "An Australian study of generic competencies required by engineers", European Journal of Engineering Education, 2011, vol. 36, no.2.

[7] McKenna, B., "How engineers write", Applied Linguistics, 1997, vol. 18, no.2, pp.189-211.

[8] Mort, P. & Drury, H., "Supporting student academic literacy in the disciplines using genre-based online pedagogy", Journal of Academic Language and Learning, 2012, vol. 6, no.3, A1-A15.

[9] Trevelyan, J., "Engineering education requires a better model of engineering practice", Proceedings of the Research in Engineering Education Symposium 2009, Palm Cove, Qld.

[10] Trevelyan, J., "Mind the gaps: Engineering education and practice", Proceedings of the 2010 AaEe Conference, UTS, Sydney NSW.

[11] Carter, M., Ferzli, M. &Wiebe, E., "Writing to learn by learning to write in the disciplines", Journal of Business and Technical Communication, 2007, vol. 21, no.3, pp. 278-302.

[12] Herrington, A.J., "Writing in Academic Settings: A study of the contexts for writing in two college chemical engineering courses", Research in the Teaching of English, 1985, vol. 19, no.4, pp. 331-361.

[13] Hilgers, T.L., Hussey, E. &Stitt-Bergh, M., "'As you're writing, you have these epiphanies': What college students say about writing and learning in their majors", Written Communication, 1999, vol. 16, pp. 317-353.

[14] Wheeler, E. & McDonald, R.L., "Writing in Engineering Courses", Journal of Engineering Education, October 2000, pp. 481-486.

[15] Bucciarelli, L, Einstein H.H., Terenzini P.T., and Walser A.D., "ECSEL/MIT engineering education workshop '99: A report with recommendations", Journal of Engineering Education 2000, vol. 89, no.2, pp. 141–50.

[16] Godfrey E. & Parker L., "Mapping the cultural landscape in engineering education", Journal of Engineering Education vol 99, no.1 January 2010, pp. 5–22.

[17] Radcliffe, D. "Shaping the discipline of engineering education", Journal of Engineering Education, 2006, vol. 95, no.4, pp. 263–64.

[18] Dym C., Agogino A., Eris O., Frey D. & Leifer L. "Engineering design thinking, teaching and learning", Journal of Engineering Education, 2005, vol. 94, no.1, pp. 103-120.

[19] Wulf, W.A. & Fisher, G.M.C., "A Makeover for engineering education", Issues in Science & Technology, Spring 2002.

[20] Seymour E. & Hewitt N. Talking About Leaving: why undergraduates leave the sciences, Westview Press, Boulder, Colorado ,1997.

[21] Sheppard, S., Macatanga, K., Colby, A., & Sullivan, W.M., Educating Engineers- Designing for the Future of the Field, Jossey-Bass, San Francisco, 2009.

[22] Pawley, A. 2009, "Universalized narratives", Journal of Engineering Education, October 2009, vol. 98, no.4, pp. 309-319.

[23] Bernstein, Basil B. Pedagogy, symbolic control, and identity: theory, research, critique, Rowman & Littlefield, Lanham Md., 2000.

[24] Maton, K., "Analysing knowledge claims and practices: Languages of legitimation", in Social Realism, Knowledge and the Sociology of Education: Coalitions of the mind, K. Maton, & R. Moore, Eds. London, Continuum, 2010, pp. 35-59.

[25] Geirsdóttir, G., "Teachers' conceptions of knowledge structures and pedagogic practices in higher education". In Knowledge and identity: Concepts and applications in Bernstein's sociology, G. Ivingson, B. Davies and J. Fits, Eds. London, Routledge, 2011.

[26] Muller, Johan, "Forms of knowledge and curriculum coherence", Journal of Education and Work, 2009, vol. 22, no.3, pp. 205-226.

[27] Wolff, K. & Luckett, K., "Integrating multidiscipinary engineering knowledge", Teaching in Higher Education, 2013, vol. 18, no.1, pp. 78-92.

[28] Macken-Horarik, M., "Building a knowledge structure for English: Reflections on the challenges of coherence, cumulative learning, portability and face validity", Australian Journal of Education, 2011, vol. 55, no. 3, pp. 197–213.

[29] Winsor, D.A., "Engineering Writing/writing engineering", College Composition and Communication, 1990, vol. 41, no.1, pp. 58-70.

[30] Goldberg, D. 2009, The Missing Basics, http://philsci-archive.pitt.edu/4551/1/deg-grasso-2009-the-missing-basics.pdf

[31] Reich, A., Rooney, D., Gardner, A., Willey, K., Boud, D. Fitzgerald, T., "Engineers' professional learning: a practice-theory perspective", European Journal of Engineering Education, 2015, vol. 40, no.4, pp. 366-379.

[32] Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L., Changing Practices, Changing Education, Singapore, Springer, 2014.

[33] Schatzki, T., "A Primer on practices", in Practice-Based Education: Perspectives and Strategies, J. Higgs et al. Eds., 2012, Sense Publishers, pp. 13-26.

[34] Kemmis, S. & Mutton, R., "Education for sustainability (EfS): practice and practice architectures", Environmental Education Research, 2012, vol. 18, no.2, pp. 187-207.

[35] Watt. R. Concordance, 2011. http://www.concordancesoftware.co.uk/

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How can the development of writing practices in the engineering curriculum be enabled?

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CONTEXT
Competence in written communication is regarded as a critical requirement for engineering graduates and engineering educators alike, but the development of writing within the engineering curriculum is frequently invisible, and occasionally non-existent. This is despite repeated calls from EA and employer groups for Australian engineering faculties to improve the communication skills of their engineering graduates. It is also despite several decades of excellent initiatives and interventions to support and develop engineering students' written and spoken communication, many of which have fallen into disuse once their champion has moved on.

PURPOSE
This study seeks to investigate and provide answers to the following research questions: why are writing practices unsustained in the current Australian engineering curriculum? What would make them thrive?

APPROACH
The study involves engineering academics from several Australian engineering faculties as participants, and investigates their views of how writing is developed in the subjects that they teach. This paper presents the analysis of one participant's site of practice. The approach uses the theoretical perspective of practice theory. Interviews, documents and participant observations are analysed using practice architectures theory to reveal what constrains the development of writing practices as part of the engineering curriculum.

RESULTS
Key results show that the development of writing within engineering subjects is currently not seen as a key part of doing engineering, and that modelling or practising writing is not seen as part of the subject coordinator's role. It also reveals that engineering academics can have a lack of agency about developing the writing practices of their students.

CONCLUSIONS
If writing is to be developed intrinsically in the engineering curriculum, there will need to be practice architectures which enable rather than constrain practices of writing. These changes may include reframing writing practices as part of what engineers do.

KEYWORDS
Engineering writing, engineering curriculum, practice architectures, practice theory.

Context

According to Australian engineering faculty graduate attributes and Engineers Australia competencies, the attainment of written (and spoken) communication skills in engineering students is an intended outcome of the Australian engineering curriculum (EA 2013). Employers certainly expect engineering graduates to be proficient communicators:

Employers expect recent [engineering] graduates to be able to communicate clearly and professionally. The expected abilities for communicating clearly include using correct spelling and grammar most of the time; being concise; giving sufficient explanation; and giving clear, high-level overviews (Ruff & Carter, 2015, p.138).

However, it is difficult to ascertain where written communication skills are developed within the curriculum, even with a close examination of subject outlines or by mapping graduate attributes. Such investigations can reveal where writing does or does not take place, but may not indicate how writing in the context of the subject is practised, nor how the subject coordinator sees writing. Such a lack of visibility demonstrates a perceived lack of value for these skills. As Charles Bazerman notes, "What is not institutionally visible does not count" (Bazerman 2003); he is referring to the lack of visibility of writing in the American education context, but similar claims could be made about writing in the Australian engineering curriculum. The invisibility is perhaps greater here.

A partial explanation for the invisibility of writing in the engineering curriculum can be found in the rationalist view of writing which prevails both in engineering and in the broader university curriculum. This sees language as transparent and value-free, and is based on "the assumption that students learn a neutral, transparent medium in order to learn an epistemologically transparent message" (Turner 1999, p.158). The view of language as a neutral medium also supposes that all discourses will be unproblematically acquired under normal circumstances. This perspective regards language (writing) as purely a means of conveying the content, with the implication that problems with writing are caused by defects in the writer's understanding or logic (Turner, 1999), not by student writers being unfamiliar with the language of the discipline in which they are learning to participate.

The social practices or socio-cultural view of writing challenges the rationalist view and sees writing as a situated social and cultural practice, where people learn to write by participating in meaningful literacy practices (Ivanic 2004; Lea & Street 1998; Lillis, 2008; Turner 2004; 2011). As the term suggests, *writing as a social practice* is embedded in the context in which the writing takes place, and people "learn implicitly by participating in socially situated literacy events which fulfil social goals which are relevant and meaningful to them" (Ivanic 2004, p. 235), and underpins many initiatives that seek to develop writing in engineering.

When these two views of writing are contrasted it becomes easier to see why the rationalist view of writing holds sway over the engineering curriculum; it sees writing as a vehicle for conveying technical knowledge. The writing that is produced in engineering subjects is a by-product or artefact (e.g. engineering reports); research is done in labs and then 'written up', as though the research and the writing were separate, with the latter being a perfunctory and mechanical procedure. Writing is generally not practised in class, either by showing examples of required assessment tasks or as a way of consolidating students' learning. The impact of separating writing from learning in engineering can lead to undesirable outcomes, such as graduates who cannot communicate their technical knowledge, who struggle to analyse or evaluate key information, and who do not necessarily see links between the theories that they learn and are expected to reproduce under exam conditions, and putting theory into practice. Not knowing how to write for different audiences is another major possible outcome, as is noted by Braine (1989):

> *"When [science and technology] students write for their subject teachers who are already fully informed of the subject matter, there is no need to be persuasive or argumentative: masses of*

data can be regurgitated, often in a rambling and disorganized fashion. Subject teachers may only check for content…" (Braine,1989, p.13).

Professional engineers are expected to communicate to a wide range of stakeholders from diverse backgrounds, but it is difficult to see where in the curriculum they get practice in doing this. As the above quotation illustrates, there is rarely an explicit expectation for students to organise, persuade, or argue: as long as the 'content' can be found in the student text, it will frequently be assessed as 'satisfactory'.

The underlying assumption is that students will acquire the necessary writing skills by osmosis through exposure to the expert writing of their instructors. The rationalist view of writing does not consider what happens when, for example, there are lecturers who are not proficient writers themselves, either because they are teaching in their second language or because they are products of an engineering curriculum that does not practise or develop writing.

According to this perspective, students who enter an engineering degree program with less than adequate writing abilities need to be 'fixed', usually by a stand-alone communication subject or by generic workshops on writing which are decontextualised from disciplinary knowledge (Wingate 2006). This assumption also positions the development of writing in engineering as someone else's problem, as evidenced in this quote from a US engineering academic: "…it's not my job to teach them how to write; I'm not a writing instructor" (Kranov, 2009, p. 14.1.6). Similar perspectives from Australian engineering academics have been reported on in a study by Author A & Author B (2016).

In order to address this gap in the engineering curriculum, many initiatives and interventions using a range of approaches have attempted - often successfully - to develop engineering students' writing in an engineering subject or across an engineering program (e.g. Carter, Ferzli, & Wiebe, 2007; Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999; Lord, 2009; Mort & Drury, 2012; Pflueger, Weissbach, & Gallagher, 2015). However, when the funding has run out or the champion has moved on, the engineering curriculum reverts to the default engineering science focus, with its emphasis on technical knowledge that can be tested by short-answer examinations measuring individual knowledge acquisition or reproduction of facts. Writing in the engineering curriculum, whether as a means of writing to learn or as a form of communicating ideas, withers on the vine again.

Purpose

The range and number of interventions that seek to address student writing in engineering demonstrates the continuing need for something to shift in the engineering curriculum. It also raises the question of what holds the practices in place that prevent writing from being seen as part of what engineers do, on par with calculations, measurements and working with formulae. There is little research in this area, and even less on the perspectives of engineering academics about writing in the degree programs in which they teach, which makes the current study timely, highly relevant and original. In this study, we are attempting to identify what keeps writing in the margins of the engineering curriculum; why do so many initiatives succeed in the short term only to fade away when the people behind the change move on? Another research question that emerges is what it would take to make writing part of the learning process of doing engineering. In attempting to answer these questions, we have decided to explore engineering academics' perspectives of writing in the engineering curriculum; thus the focus is on individual engineering academics, the subjects they coordinate, and the writing practices that are part of their subject.

We are looking at the practices that are enacted in this context; 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. These practices include opportunities for students to practise or develop proficiency in different types of writing, and approaches to assessment of student writing. As practices are at the centre of what is being investigated, it is logical to use practice theory as a theoretical and methodological perspective. Previous publications based on this study have used activity theory as interpreted by Engestrom (2003); (Goldsmith & Willey 2015; 2016); for this paper we are using the lens of practice architectures theory. An examination of the arrangements – the practice architectures – that hold the invisibility of writing practices in the engineering curriculum in place, can provide an understanding of how this situation has come about, and suggest ways of making sustainable change. The application of practice architectures theory provides a way of revealing "deeply embedded beliefs and taken-for-granted discourses...that can enable and constrain the practices of...educators" (Salamon, Sumsion, Press & Harrison 2014 p. 1).

Practice architectures theory (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 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.

An example of practice architectures of writing practices in the engineering curriculum in a particular engineering faculty might be as follows: comments by students and staff such as "You don't need to be able to write to be an engineer" (cultural-discursive arrangements); assessment tasks that involve no writing (material-economic arrangements); assessment criteria for written assignments that do not include the quality of writing , in addition to the "low status of teaching compared to research in many institutions" (Goodhew, 2010, p. 95) (social-political arrangements). These arrangements interact with one another not only to constrain the learning of writing practices but also to enable learning that valorises the acquisition of knowledge which can be reproduced and measured by short answer exam questions. The application of PAT as an analytical tool uses practice architectures in combination with the sayings, doings and relatings of participants in a site of practice to reveal how practices influence practice architectures and vice versa. This relationship is illustrated in figure 1, which shows how the elements of a practice, represented by the circular arrows within the diagram (sayings, doings and relatings) are held in place by practice architectures, represented by the circles of the diagram (the arrangements). All of these interact with one another to enact the project, represented by the large horizontal arrow, which is the intended outcome of the practice.

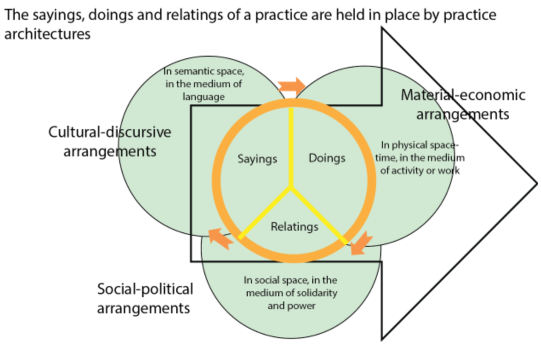

Fig.1: Practice architectures (Adapted from Kemmis 2013, p.3)

Approach

The first phase of this study was the recruitment of engineering academics who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities. Subject coordinators were selected as they have considerable control over subject content, teaching approaches and assessment practices. Potential participants at a number of Australian universities were contacted by email and invited to participate. Nine participants were recruited from five institutions; 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. For this paper we looked at how writing and communication skills more generally are spoken of in engineering faculties (cultural-discursive arrangements); what assessment tasks students are expected to do in their engineering subjects and whether and how subject coordinators demonstrate writing practices (material-economic arrangements), and the extent to which subject coordinators feel able to support students' writing in their subject (social-political arrangements). These arrangements are analysed in the *practice landscape* (Hemmings, Kemmis & Reupert, 2013, p.475) of the participants: the engineering subjects coordinated by the participants. The evidence for the practice architectures is provided by the analysis of documents such as subject outlines, descriptions of subjects and programs on the university website, assignment specifications and criteria for assessment provided by the subject coordinator, and interview comments. The evidence for the elements of practices in the sites of practice comes from the interviews, supported by the document analysis.

Results

This section presents a PAT analysis of one participant's site of practice in the light of two key themes that have emerged from the study: 1. *Writing is not seen as a key part of doing engineering; 2. Modelling/practising writing is not seen as part of the subject coordinator's role.* The participant is Garth from University C (all participants and their institutions have been de-identified and given pseudonyms in accordance with ethical conduct for qualitative research).

The practice landscape (Garth's subject) is a 3rd year engineering subject, with a cohort size of approximately 300. The students in his subject have done two years of civil engineering, and Garth's subject introduces them to the key concepts involved in a specific aspect of civil engineering. The *Project* (the intended outcome) of Garth's site is to make sure that students cover many different topics that are included in Garth's subject. The following analysis shows the practice architectures – what keeps the practices in place - of Garth's site of practice, which is the subject that he teaches, how he teaches and assesses it, and what students are required to do in his subject. We examine also the elements of practices – the sayings, doings and relatings – that are enabled or constrained by the practice architectures. The analysis focuses on the practice architectures as they relate to the key themes.

Theme 1: Writing is not seen as a key part of doing engineering

The cultural-discursive arrangements and sayings: Garth's subject outline states: "assumed knowledge: previous subjects in engineering" (Garth subject outline 2013 p.1).

Students are in the third year of their engineering degree program. There is no expectation that students would have knowledge of how to write descriptions, although they are required to do this in final exam: "they have to describe some standard process of …system design…" (Garth, interview). If a certain level of writing competence is not a stated expectation in the subject, students can assume that it is not necessary or that it is of low status.

The subject outline has 6 learning outcomes, including: "5. Apply a professional dialogue with specialists and non-specialists by way of written documents and drawings" (Garth subject outline 2013 p.1) but there is no mention of writing or drawing in the description of content or of assessment tasks. If these forms of communication are not made visible in the subject documents, they can be regarded as not important (Bazerman, 2003).

Assessment criteria for the assignments are provided in separate documents. The assessment criterion for communication in the 1st assignment is: "Demonstrate effective written communication to an audience of discipline specialists"; it has descriptors that allocate marks for correct formatting, correct spelling & neat drawings. There are no descriptors for effectiveness of communication. Garth comments that a few years ago he would have expected students to be able to write descriptions, but now he knows the students so he no longer has that expectation. Students look to the subject coordinator and to the subject documents to provide guidance on what they are expected to do and learn in the subject, and at what level. If students do not see that they are expected to write at a certain level, the majority will put in sufficient effort to complete a task, and will focus on learning the propositional or technical knowledge that is tested in an exam (see also Gardner, Goldsmith & Vessalas, 2016). Garth acknowledges the lack of emphasis on writing in the curriculum of his faculty:

> *Writing practice was not sufficiently highlighted in the current curriculum. We believe it's quite important but there are so many other important things that we want to include and teach* (Garth, interview).

The subject outline lists a group project as one of the assessment tasks, but does not use the word 'report'. It refers to the 'submission documentation'. A common challenge for students is to decipher the expected format of written assessment tasks; the difficulty of the challenge increases when subject coordinators use instructional words interchangeably (submission/report) or add confusion through a lack of clarity.

Material-economic arrangements and doings: The weighting of assessment tasks is 20% for each of two assignments, 60% for the final exam; this directs students to focus on propositional (technical) knowledge. Garth replaced the group project with assignments that require students to solve mathematical problems, possibly in order to cover all the topics that were seen to be important:

> *The two assignments, the students don't have to write anything in professional style. It is actually just problem solving questions. So they don't really have to describe anything, all right, they just solve some mathematical questions in transport and that's it. That really doesn't count, not really relevant but we still have it [in the subject outline]* (Garth, interview)

Weighting of different assessment tasks shows the relative importance of types of knowledge in the subject/curriculum: the emphasis is on knowledge that can be reproduced under exam conditions.

Social-political arrangements and relatings: Feedback on writing occurs only after the students submit the assignments for assessment; this sets up writing as a performance to be produced and assessed summatively in assignments and the exam, but not practised throughout the semester. This can reinforce the message to the students that they do not need to focus on the quality of their writing. Garth recognises that writing is important but it is more important to cover as many topics as possible; writing becomes a lower priority and is seen by students (and some staff?) as something not to be taken seriously.

> *Interviewer: So do you actually comment on anything when you're marking the exams?*

Garth: That's a good question. I used to do that but not anymore…Because I don't think students really read my comments and take it seriously (Garth, interview).

Theme 2: Modelling/practising writing is not seen as part of the subject coordinator's role

Cultural-discursive arrangements and sayings: Information in the subject outline and additional assignment documents outline the assessment task but say nothing about writing or about producing a report. The final summative exam is expected to measure learning outcome 5, but there is no provision of practice or of modelling of the "professional dialogue":

> *...in their final exam questions there are some question types that they have to describe some standard process of …system design...We try to look at their writing style; if their writing style is professional or is just a very casual style. We try to include that in our writing criteria* (Garth interview).

Somehow the students are expected to acquire the ability to "apply a professional dialogue", without practising in class or in the assessment tasks, and without seeing a model of the kind of writing they might aspire to produce. And yet they are examined on this.

Material-economic arrangements and doings: The teaching activities in tutorials emphasise practising technical questions. Writing is assessed in the final exam but not practised in the tutorials. Garth does not show 3rd year students his writing as he does not see it to be relevant (but he shows his research writing to the 4th year thesis students). "We have tutorials every week and we don't miss any tutorial. But, we use most of the tutorial times to practise those technical questions". In response to the question: do students get opportunities to practise the kind of writing that they're being asked to produce in the exam? Garth: "Unfortunately no. That's a good point". The doing in the tutorials is all about practising the technical questions. This also relates to the 1st theme in this analysis, as Garth (who is by no means alone in this) can separate the practice of technical knowledge from writing/communicating, but does not seem to be able to put them together, to see that practising technical questions can be combined with students discussing, explaining, clarifying with one another verbally and in writing.

Social-political arrangements and relatings: The assessment practices emphasise getting marks, so students will focus on feedback on their writing only when it can impact their grades. There is a significant shift in expectations from both engineering academics of fourth year students, and from the fourth year students themselves about the importance of writing because the major assessment task is a written artefact of some kind: often a capstone project report or an honours thesis. Students below fourth year are not expected to take writing seriously; they are at the very outer edge of the community of practice and are not shown the subject coordinator's research writing. Garth comments that: "But I found that most of the students don't have that thing [know how to write descriptions, justifications] in their third year" (Garth, interview). It then becomes a mystery as to where the students will acquire this knowledge, if it is not made explicit, not practised, and not emphasised. When the expectation is made explicit, there appears to be a miraculous transformation:

> *But, I think in their fourth year their writing skills actually improve somehow... Well, some students take the fourth year project more seriously than the third year. That's why it's better; their practices improve their writing skill* (Garth, interview).

Equally miraculous is where the practices come from, if not from the learning that students do in their subjects.

Discussion

From this analysis we can see how the application of PAT can uncover the 'silent narratives' (Bone, 2008 in Salamon et al. 2014) that construct the practices within Garth's practice landscape. The analysis of the evidence for themes 1 and 2 (writing is not seen as a key part of doing engineering; modelling/practising writing is not seen as part of the subject coordinator's role) shows how the interaction of the three types of arrangements works to hold practices in place. The prevailing impression is that of a subject coordinator whose teaching practices are shaped by the practice architectures of his faculty, of his school and of the colleague in his school, and of his previous experiences. These practices enable the acquisition of technical knowledge divorced from writing, and simultaneously constrain the development of writing as part of what and how his students could learn. As has previously been noted, the separation of writing from content can result in students (graduates) focusing on reproducing information without considering who is to read it, or how it is to be understood and interpreted.

These practices consolidate the cultural-discursive arrangements that can be detected in many engineering subjects where writing or communication skills are seen as separate from technical knowledge. Furthermore, what is *not* said is also part of the cultural-discursive arrangements: if writing/communication is not listed as a subject or task learning outcome, it has no presence for the students. When this effect is multiplied over the majority of engineering subjects, the impact is strong and clear: engineering is about technical knowledge, and has little to do with communication.

Because of these pressures, it becomes unthinkable and undoable to have writing practices take up space in the teaching activities of his subject, "because there are so many other important things that we want to include and teach". Garth's comment illustrates how the cultural-discursive arrangements, material-economic arrangements and social-political arrangements interact to constrain the practice of writing in the engineering curriculum. There is too little time in the class or the semester, or it is not someone's job to teach writing, or writing is important but not quite as important as the technical or propositional knowledge taught by the subject coordinator.

> *So we have too many things that we want to teach and we only have 13 weeks. So we actually use tutorial times, most of the tutorial times, to teach something, do a practice. So I thought that is the best way to utilise the time but by doing that there's no practice actually for a student to improve their writing skill* (Garth, interview).

As has been previously noted, Garth does not see opportunities to link written or oral communication with technical knowledge. There is also a sense from his interview comments that Garth seems to lack agency, or to be unwilling to exercise it. He recognises that there are gaps in the system, commenting on this several times throughout the interview, but does not take steps to address these gaps, even when it is within his control to do so. It may be that the practice architectures of his faculty seem so immovable to him that any actions of his would be futile. On the other hand, his is not the only subject outline that claims to develop communication skills without including teaching, learning, or assessment activities that provide opportunities for writing or speaking (Goldsmith & Willey 2016).

Conclusions

The analysis of these practices highlights not only the absence or invisibility of writing practices in a subject, but how and why writing/ communication more generally, becomes invisible throughout the engineering curriculum. It also shows a way forward. If engineering academics can start to say and think that writing is part of engineering, if they include writing and discussing as part of the learning practices of their subjects, if they begin to value communication as a core graduate attribute that they can develop in their students, written and spoken communication can be visible and be sustained. Engineering academics do not need to teach writing, but they do need to practise it, as writers and as educators.

References

Bazerman, C. (2003). What is not institutionally visible does not count: The problem of making activity assessable, accountable, and plannable. *Writing selves/writing societies: Research from activity perspectives*, 428-83.

Braine, G. (1989). Writing in science and technology: An analysis of assignments from ten undergraduate courses. *English for Specific Purposes,* 8, 3-15.

Carter, M. Ferzli, M., & Wiebe, E. (2007).Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*, *21*, 278.
Engineers Australia. (2013). Stage 1 competency standard for professional engineers https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/130607_stage_1_pe_2013_approved.pdf
Gardner, A., Goldsmith, R., Vessalas, K. (2016). Using practice architectures theory to compare consecutive offerings of the same subject.
Goldsmith, R., & Willey, K., (2015). Activity theory analysis of the visibility of writing practices in the engineering curriculum. *Proceedings of the 6th Research in Engineering Education Symposium*, Dublin, Ireland, 13-15 July 2015.
Goldsmith, R., & Willey, K. (2016). “It’s not my job to teach writing”: Activity theory analysis of [invisible] writing practices in the engineering curriculum. *Journal of Academic Language & Learning,* 10, 1, A118-A129
Goodhew, P. (2010). *Teaching Engineering: All you need to know about engineering education but were afraid to ask,* The Higher Education Academy, UK Centre for Materials Education, retrieved July 11 2016 from http://core.materials.ac.uk/repository/teaching-engineering/teaching_engineering_goodhew.pdf
Hemmings, B. Kemmis, S., & Reupert, A. (2013). Practice architectures of university inclusive education teaching in Australia. *Professional Development in Education*, 39(4), 470-487.
Herrington, A.J. (1985). Writing in academic settings: A study of the contexts for writing in two college chemical engineering courses. *Research in the Teaching of English*, *19*(4), 331-361.
Hilgers, T.L., Hussey, E., & Stitt-Bergh, M. (1999). “As you’re writing, you have these epiphanies”: What college students say about writing and learning in their majors. *Written Communication*, *16*, 317-353.
Kemmis, S. (2013). The theories of practice architectures and ecologies of practices. http://ips.gu.se/digitalAssets/1467/1467159_kemmis-pep-theory-tromso.pdf [accessed 3.8.16]
Kemmis, S. & Mutton, R. (2012). Education for sustainability (EfS): practice and practice architectures. *Environmental Education Research,* 18(2), 187-207.
Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L. (2014). *Changing Practices, Changing Education*. Singapore, Springer.
Kranov, A. A. (2009). "It's Not My Job To Teach Them How To Write": Facilitating The Disciplinary Rhetorical Socialization Of International ESL Graduate Assistants In The Sciences And Engineering, *ASEE 2009 Annual Conference & Exposition*, June 14-17, Austin, Texas. https://peer.asee.org/5093
Lea, M.R., & Street, B.V. (1998). Student writing in higher education: An academic literacies approach. *Studies in Higher Education*, *23*(2), 157-172.
Lord, S.M. (2009). Integrating effective ‘writing to communicate’ experiences in engineering courses: Guidelines and examples. *International Journal of Engineering Education*, *25*(1), 196-204.
Mort, P., & Drury, H. (2012). Supporting student academic literacy in the disciplines using genre-based online pedagogy. *Journal of Academic Language and Learning*, *6*(3), A1-A15.
Pflueger, R., Weissbach, R., & Gallagher, S. (2015). Strengthening technical writing knowledge transfer through targeted study in a first-year composition course. *Proceedings of the Research in Engineering Education Symposium*, Dublin, 13-15 July 2015.
Ruff, S., & Carter, M. (2015). Characterizing employers’ expectations of the communication abilities of new engineering graduates. *Journal on Excellence in College Teaching*, 26(4), 125-147.
Salamon, A., Sumsion, J., Press, F. & Harrison, L. (2014). Implicit theories and naïve beliefs: Using the theory of practice architectures to deconstruct the practices of early childhood educators. *Journal of Early Childhood Research,* 1-13.
Schatzki, T. (2012). A Primer on practices. In J. Higgs, R. Barnett, S. Billett, M. Hutchings & F. Trede (Eds.) *Practice-Based Education,* Rotterdam, Sense Publishers.
Turner, J. (2011). *Language in the Academy*, Bristol: Multilingual Matters.
Wingate, U. (2006). Doing away with study skills. *Teaching in Higher Education,* 11 (4), 457-469.
Watt. R. (2011). *Concordance*. Retrieved from http://www.concordancesoftware.co.uk/
Wheeler, E., & McDonald, R.L. (2000). Writing in engineering courses. *Journal of Engineering Education*, October 2000, 481-486.
Winsor, D.A. (1990). Engineering writing/writing engineering. *College Composition and Communication*, 41(1), 58-70.
Winsor, D.A. (1996). *Writing Like an Engineer: A Rhetorical education*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.
WRiSE (2012). Retrieved July 31, 2015, from http://www.usyd.edu.au/learningcentre/wrise/

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"It's not my job to teach writing": Activity theory analysis of [invisible] writing practices in the engineering curriculum

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Although writing is still the main form of assessment at university, the practice of writing continues to be marginalised, particularly in technical disciplines such as engineering, notwithstanding decades of reports identifying gaps in graduate communication abilities in these fields, and diverse interventions to address these gaps. The assumption underlying many of the reports and interventions is that engineering students neither value nor are interested in writing, but actually many engineering students are not provided with the opportunity to develop or practise disciplinary writing in the subjects they study, despite being required to write in a range of genres as part of their assessment. This implies that writing practices are neither seen as developmental nor as intrinsic to the engineering curriculum. This demands the question: why not? This paper reports on a study investigating perceptions of writing practices in the engineering curriculum at the level of engineering academics. Using activity theory to capture the dynamic interactions of the various participants in engineering subjects, the study analyses the perspectives of engineering subject coordinators about writing practices in their subjects through interviews and documents. Current findings show tensions between the value of propositional or technical knowledge and that of writing practices. These findings can be used to develop a discussion with engineering academics to emphasise the developmental nature of writing and to make writing practices more visible in the engineering curriculum.

Key Words: activity theory, writing in engineering, disciplinary writing.

1. Introduction

Although writing is still the main form of assessment at university, the practice of writing continues to be marginalised (Turner, 2011); Swales refers to "an ivory ghetto of remediation" in regard to academic literacy within the institutional discourse of academe (1990, p. 11). This is particularly the case in technical disciplines such as engineering. It appears that decades of reports identifying gaps in graduate communication abilities in these fields, and diverse interventions to address these gaps have had little lasting impact. These reports focus mainly on employer expectations, which consistently list communication as one of their top five necessary or desirable attributes (Accreditation Board for Engineering and Technology [ABET], 2011; King, 2008; Royal Academy of Engineers, 2007; Sheppard, Macatangay, Colby, & Sullivan, 2009). When these reports are examined in more detail, the ability to write persuasively and concisely is identified as being a necessary part of engineering practice.

The assumption underlying many of the reports and interventions is that engineering students neither value nor are interested in writing. The deficit model of the linguistically impoverished engineering student is a recurring feature in the literature both in Australia and overseas (Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999). However, this view is rarely interrogated; few if any studies explore the extent to which students commencing an engineering degree are less competent in writing than their peers in other disciplines, although there is anecdotal evident to support this (Mort & Drury, 2012; Pflueger, Weissbach, & Gallagher, 2015).

The root causes of engineering students' poor writing proficiency may be complex and difficult to tease out; however, the actuality is that many engineering students are not provided with the opportunity to develop or practise disciplinary writing in the subjects they study. This is despite the fact that they are expected to write in a range of genres as part of their assessment. In order to address the perceived deficiencies in student writing, a wide range of strategies and interventions have been implemented over several decades and in several continents. The majority of interventions reported in the literature cover the gamut of writing development models (Lea & Street, 1998) from study skills to socialisation within the discipline to academic literacies (Carter, Ferzli, & Wiebe, 2007; Lord, 2009; Mort & Drury, 2012), and generally provide models, exemplars and scaffolded writing exercises around authentic tasks. The US examples occasionally utilise the first year composition classes to introduce engineering topics and/or report genres (Pflueger, Weissbach, & Gallagher, 2015). Unfortunately, most of these interventions lack sustainability. The intervention, no matter how well-considered, timely, relevant and effective, is likely to disappear as soon as the writing champions move on, lose funding, undergo an organisational restructure or collapse from exhaustion and despair. It seems almost impossible to embed writing permanently in the engineering curriculum so that it is seen to be an integral element of becoming an engineer.

This suggests that writing practices are neither seen as developmental nor as intrinsic to the engineering curriculum, and thus demands the question: why not? What is it that prevents engineering students, teaching staff, heads of engineering schools and faculties from seeing writing practices as part of the engineering curriculum? What is it that causes the title of this paper to be a common refrain in the corridors of engineering faculties? In other words, what makes writing practices invisible, so that they are not seen at all, or seen as somebody else's problem, or seen only intermittently as isolated examples of good practice on the part of individual engineering academics? When we began to explore these questions, it became clear that there was a lack of research into the perspectives held by engineering academics about the place writing development should have in the engineering curriculum. There are few studies that look at how engineering academics experience writing: how they develop their writing practices, how they view writing in the engineering curriculum, how they view themselves as engineering writing practitioners, how or if they see themselves as modelling writing practices for their students. The majority of the literature examines the research writing practices of engineering academics: that is, the research papers that they write, usually as leaders or members of a research team (Curry, 2014; Koutsantoni, 2007; see also Blakeslee, 1997). Dorothy Winsor examines the writing practices of practising engineers (1990) and of novice engineers (1996); the latter study in particular contrasts the purpose and text types of the writing that novice engineers do as part of their internships with the writing they do in their engineering degree. However, gaps remain in the exploration of the understandings that engineering academics have about their own writing practices and those of their students who are doing coursework rather than research degrees.

Therefore, we have chosen to consider writing practices in the engineering curriculum by exploring the interactions between individual engineering academics, the subjects they teach, their teaching and assessment practices of the subject content and the role that writing plays. This can go some way towards providing a better understanding of how writing practices are or are not enacted in the engineering curriculum, the extent to which there is visible development of writing practices, and how engineering academics see or do not see writing practices within their subjects. Through interviews and documents, the study analyses the perspectives of engineering subject coordinators about writing practices in their subjects.

2. Methodology

The theoretical framework for this study is activity theory, which originated from Vygotsky's and Leont'ev's work in early 20th century Russia, and since the 1960s, has been used to explore learning in educational and in workplace contexts (Engestrom, 2001; Jonassen & Rohrer-Murphy, 1999). It regards learning as culturally, socially and historically situated, so that there is no Cartesian mind/body divide; learning takes place within a social context. Activity theory (AT) focuses on human actions in the context of the larger human activity in which it is situated (Dias, Freedman, Medway, & Pare, 1999, p. 23). AT thus enables an analysis of human actions in context (1999, p. 27). Because of its situated nature, AT allows researchers to explore “the wider social and cultural contexts that are grounded in the history of [a] particular professional practice” (Orland-Barak & Becher, 2011, p. 116). It also reveals internal contradictions in practices, which can be overlooked when people focus on individual process and textual products (Dias, Freedman, Medway, & Pare, 1999, p. 28). AT analysis examines these activities in the framework of an activity system. Each system comprises subjects (the actors performing activities), objects (of activities: artefacts produced, goals achieved), outcomes of objects (such as longer term goals); mediating tools that are used to carry out the activity (writing, computers, documents); the community in which the activity takes place (a faculty, a class, a university); the rules and norms that surround the activity (assessment regulations, course requirements) and the division of labour (who does what, such as who produces the assessment item, who marks it).

An activity system is usually represented as a triangle to illustrate each element of the system, how it connects to other elements, and most importantly to identify and illustrate tensions and contradictions within the system. Tensions are indicated within an activity system as breaks in the line of the triangle. AT analysis allows the researcher to capture interactions between academics, their disciplinary knowledge, their students, the mediating tools they use to achieve their outcomes, and the community in which the activity system is situated. Figure 1 shows a typical activity system.

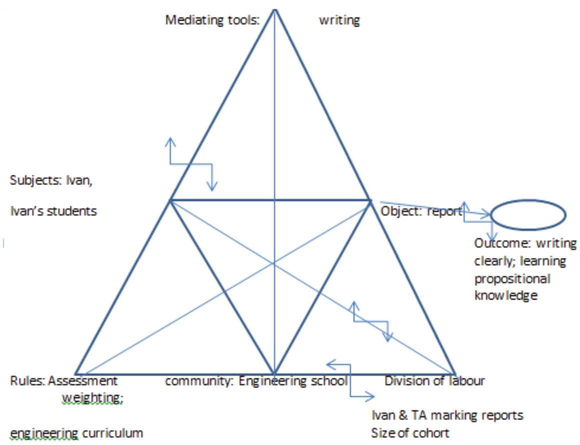

Figure 1. Example of activity system.

A key characteristic of any activity system is the occurrence of internal contradictions, which are also seen as tensions among the elements of the system. These tensions can generate disturbances, but can also bring about innovations. An example of such a tension might be in an activity system of an engineering subject where assessment tasks include a report worth 5% and an exam worth 60%; this leads to a contradiction in how students allocate time and effort to the two tasks (element of division of labour) and how they view the relevance of the two tasks to their learning (element of learning outcomes of the subject). Awareness of these conflicts can spur subject coordinators or curriculum designers to consider different types or weightings of assessment tasks.

3. Approaches

The first phase of the investigation was the recruitment of engineering academics who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities. Subject coordinators were selected as they have considerable control over subject content, teaching approaches and assessment practices. Potential participants at a number of Australian universities were contacted by email and invited to participate. Nine participants were recruited from five institutions; 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 in the analysis. 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.

The interviews were transcribed and analysed to identify key themes, using Concordance (Watt, 2011). As the themes emerged, they were examined in the context of the activity systems constructed for each of the participants, using the engineering subject as the unit of analysis. Thus thematic analysis was used to 'zoom into' the data and AT to 'zoom out' to examine the identified tensions and contradictions, following Behrend (2014) who has used action research and activity theory in a similar way. The activity systems show the interactions among the elements of the system, including contradictions and tensions between the reported perspectives of the subject coordinators about writing practices and what happens in the subject.

4. Findings and discussion

This study's findings indicate a number of tensions in the activity systems of the participants. Firstly, writing practices are taught differently, practised differently and assessed differently from propositional knowledge. Secondly, there is considerable slippage of terms used by the participants when they talk and write about writing. Both of these tensions demonstrate how writing practices can be rendered invisible in the engineering curriculum, although the activity system of one of the participants shows that this does not have to be the case. All participants and institutions have been de-identified and have been given pseudonyms for reporting purposes. Each tension is demonstrated with examples from the activity systems of participants in the study. These participants are: Adam, University A; Bernice, University A; Damien, University B; Felicity, University C; Garth, University C; Harry, University D; Ivan, University E.

4.1. Writing practices are assessed but not taught or practised; propositional knowledge is taught, practised and assessed

This tension occurs in almost all the engineering subjects. Firstly, writing practices are not specifically taught by the subject coordinators in the engineering subjects; engineering academics tend to outsource the development of writing to other work units or to student support services. Whether this is because they are not confident about providing direct instruction about disciplinary writing or because it is seen (by them) to be outside their domain is not yet clear. Most, if not all of the participants have an expectation of the type of writing that the students should be producing, and can produce this writing themselves, but are not comfortable about giving input about how the students should approach or acquire the expected style and genre. Specifications such as "professional style" or "an engineering report" do not generally provide sufficient illumination of the standards expected. It is probably not reasonable to expect that engineering academics would have in-depth knowledge about teaching writing, but it is reasonable to think that these academics should understand the importance of modelling the writing practices that they themselves have acquired, or at least provide an example of what is required in the assessment tasks that they have designed. The following comment by one of the participants about the role of writing support for their subject within their institution shows the distance between developing writing and learning propositional knowledge:

> actually they learn that also – we already have another unit [subject][1] which is run by the – I think – I'm not quite sure about the name of the unit, but for that unit they will learn how to prepare a report, how to write a report of their project or how to attempt each question of their assignment or other work. (Felicity, University C)

Clearly it is not her job to teach writing. When Felicity was asked whether the unit was specifically for engineering, she was unsure: "No. This is for – I have no idea about the other disciplines but as far as I know yes, this is similar to other ones" (Felicity, University C). In other words, students are taught generic report writing in another subject and are expected to transfer that knowledge to the very specific domain of Felicity's subject.

Secondly, in most of the activity systems writing is not practised formatively but it is assessed summatively. Garth's activity system and comments provide the clearest illustration of this contradiction. Garth has had industry experience as well as a number of years working in academia. An activity system has been constructed for a third year subject that he coordinates. In the subject outline, one of the learning outcomes is: "Apply a professional dialogue with specialists and non-specialists by way of written documents and drawings" (Garth Subject Outline Spring 2014, p. 1). However, the learning outcome related to writing is not practised, nor is there specific instruction about how to achieve "a professional writing style"(Garth interview):

> …we use most of the tutorial times to practise those technical questions. This unit is very special because this is like a flagship unit for [the engineering discipline]. So we have too many things that we want to teach and we only have 13 weeks. So we actually use tutorial times, most of the tutorial times, to teach something, do a practice. So I thought that is the best way to utilise the time but by doing that there's no practice actually for a student to improve their writing skill. (Garth, University D)

The assessment items are two assignments (20% each) and a final exam (60%). The two assignments focus on solving mathematical problems "they just solve some mathematical questions in [discipline knowledge] and that's it" (Garth interview). The exam tests the students' knowledge of theory and requires them to describe particular processes, but there are no tutorial activities to develop this type of writing, as is revealed in the following extract from the interview.

> Facilitator: So what opportunities are there for students to practise their writing in your subject?
> Interviewee: Practise?
> Facilitator: Yeah.
> Interviewee: Well, the report. That's practice isn't it?
> Facilitator: Yeah. So that's in [this subject]?
> Interviewee: Yeah. No, [this subject] is just a - well it's a math and equation.
> Facilitator: But then in the exam you're asking them to do that kind of descriptive writing so I'm just wondering through the semester do they get opportunities to practise the kind of writing that they're being asked to produce in the exam?
> Interviewee: Unfortunately no. That's a good point. (Garth, University D)

As in most subjects, the students do not have their exams returned to them, so there is no opportunity to review or learn from any writing they do.

[1] The universities in this study have different ways of referring to a unit of study: University A & E = subject; University B & D = course; University C = unit.

The activity system for Ivan's subject provides another illustration of this contradiction, and is demonstrated by differences in teaching and assessing writing as opposed to teaching and assessing propositional knowledge. It is also revealed in Ivan's attitude to both his own and his students' writing. Ivan is an engineering academic of many years' experience and has an extensive list of publications. He has also had involvement in initiatives to develop writing practices within his faculty over a number of years, seeing his subject as a flagship for ensuring that students learn how to write appropriately for their careers: "So then my subject's really where I say okay, now we've got to up the standard and expectations of writing dramatically here" (Ivan, University E). The subject for which the activity system is constructed is a second year second semester subject. The activity system includes the following tensions: between the object and the longer term outcome of the subject; between the assessment tasks requirements and the form they take (between the element of rules and that of mediating tools); between the assessment tasks and the amount of time they take to complete and to mark (between rules and division of labour), and between the assessment tasks and the object and outcome (rules, object, longer term goal). The tensions are indicated by breaks in the lines connecting the elements of the triangle (see Fig. 1). In Ivan's case, the tension between the lack of practice of writing and the emphasis on practising propositional knowledge is more pronounced because of his frequent comments about the poor quality of students' writing, and the lack of opportunities to practise the writing of the reports or to submit drafts. In this subject there are five assessment tasks; one is a computer report and one is a lab report, but only the lab report involves any substantial writing.

There is little description about what is required for either report in the subject outline, but Ivan spends at least some time telling students in the lectures what he expects in the two reports for his subject, as reported in his interview. Students are also directed to the WRiSE site to look at exemplar reports (Writing Reports in Science and Engineering, 2012). Ivan provides comments on all the reports (computer reports and lab reports), but only after they have been submitted, assuming the students will learn the expected practices from his comments on their reports and will then apply that learning in subsequent subjects. In contrast, the propositional knowledge is practised in labs, in tutorials, in work outside of class (tutorial questions to be covered before the tutorial), and with formative feedback provided in the tutorials. At the same time, there is some conflict between the amount of time and effort that goes into providing feedback for the writing compared to the feedback provided for the propositional knowledge (division of labour in the activity system). A recurring comment is the increasing size of the cohort in the subject (from 100 in 2009 to 300 in 2014) and how difficult it is to mark the number of reports and to give meaningful comments. In spite of this, Ivan persists, and marks all the computer reports himself, including written comments. The lab reports are marked by him and by one of his PhD students (after a marking standardising meeting). The technical content (calculations) can be marked with ticks and crosses.

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. A striking feature of Ivan's responses in the interview is the emotional tenor of his comments about writing (e.g. depressing, dreadful, pleasant, frustrating, happy, hated, hopeless, horrified, jaundiced), compared to the lack of affect in his comments about the propositional knowledge of his subject. What is also striking is the language he uses around the propositional knowledge in his subject, which he refers to as "simple", "basic", "calculations", "just sums". Writing obviously resonates more in the affective domain for him, perhaps because it is so much more than "just sums". It could be construed that on one level he recognises the complexity of writing compared to what he sees to be the relatively straightforward nature of the knowledge in his subject, but at the same time he sees the propositional knowledge as more important, and less contested.

As has been discussed in Goldsmith and Willey (2015), Adam's activity system (Adam, University A) demonstrates a notable contradiction in the practice of propositional knowledge compared to writing practices in his subject. Report writing is stated as one of the learning outcomes: "Students learn to structure their reports according to expectations in engineering practice" (Adam Subject Outline Autumn 2014, p. 1). The students are required to write three reports, but it is not until the third assignment description that the word "report" is used: "Any assumptions needed to develop the design [specifications] need to be discussed in the assignment report" (Adam Subject assignment 3 description 2014). Adam makes the comment:

> I tell them what I want in terms of that but I don't really give them an example of one. What I would suggest is it's really a hurdle that - they've got to get over the hurdle without a lot of actual marks being attributed to that component (Adam, University A).

It is concerning that this seems to be a practice in engineering education that is not challenged: students are assessed on learning outcomes that have not been taught or practised. Somehow, writing practices are invisible, both to teaching staff and to students. If the same practices occurred with propositional knowledge, students would protest vehemently and there would be faculty procedures to sanction the subject coordinators. This prompts the question: what is it that makes writing so 'other'?

4.2. Assessment weighting of written assignments vs exams

This tension is strongly linked to the previous one in many of the activity systems, where exams have much greater weighting than written assignments. An example of this is Ivan's subject where the assessment weighting of the written assignments is far less than the weighting given to propositional knowledge as measured by quizzes and exams (see below for the assessment tasks and weightings).

Assessment Tasks
Assignment 9% (team) Assignment 9% (computer/excel) Lab Report 10% Quiz 12% Final Exam 60%
(Ivan Subject Outline Spring 2014)

There is considerable tension both within the activity system and within Ivan himself: he expresses so much distress about the poor quality of the students' writing: "You can't read it, it's just dreadful" (Ivan, University E), and has put a great deal of thought and work into ensuring that there are assessments of writing, but can only give this task 10% of the total marks for the subject. This is acknowledged both explicitly in the interview and in Ivan's choice of words; the frequency with which he uses the word "serious/seriously" in the context of student writing or their attitude to the writing tasks demonstrates this.

> some students always respond oh, if I'd have known that was serious at the start I would've done it differently, I mean so I don't know quite whether it's because they're not taking it seriously and they were capable of doing it.

Later in the interview he makes the following comment, suggesting he is aware that the students would take the task more seriously if it were worth 20% rather than 10%[2]:

> Yeah, 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 of the mark. Well if I made it 20 per cent would you do a better job? I think they would (Ivan interview)

This then begs the question: why not increase the weighting? If it causes so much angst, why not give it more face value? It is one of the contradictions that emerges not only in the activity system but throughout the interview; it appears that the writing is a different kind of knowledge, separate from the propositional knowledge, and not as important. In his response to a question about the learning outcomes, Ivan says:

> Yeah, so I mean the main learning outcomes are to do with learning the technical content, so but tacked on at the end is ability to, yeah actually I don't remember them, but there's something about writing a lab report and there's something about the computer skills or something like that. So it's intended to be addressing the generic skills. (Ivan, University E)

[2] Note that the subject outline states that the lab report was worth 10%, but in the interview Ivan stated that it was worth 8%.

And there you have it. It’s “tacked on at the end” (his words), and writing is “lumped in” with computer skills as a generic skill.

All of the preceding tensions then lead to the next contradiction: unlike propositional knowledge and technical skills, writing practices are not seen as developmental. This tends to render them invisible, because there is a reluctance to acknowledge what is involved in developing writing, either within or beyond the individual engineering subject. The majority of participants did not feel confident about commenting on the development of writing throughout the engineering curriculum. Damien was the one participant who could comment on this, but only within his school and in the context of report writing for his discipline. The other participants either were unable to comment or were keenly aware that development of writing was at best ad hoc, and at worst almost non-existent.

> Interviewer: Do you think students can develop their writing practices in this curriculum?
>
> Bernice: I think they have opportunities to do that if they see them as opportunities to develop their writing but I don’t think anyone, or in a lot of cases, the opportunities are flagged as well yes you've got to calculate this stuff. It's about doing the calculations, it's not flagged as this is also an opportunity to learn to write as a practising whatever type of engineer you're planning to become (Bernice, University A)

Another comment from Ivan about the somewhat random development of writing in his faculty (which could equally apply to many engineering faculties):

> … so it's what we do is we set the levels, right. So it's level one, level - and each level's meant to be higher attainment. But in reality they kind of [do] level one, level one, they do my course as level four and then the next one's back to level two. It's sort of, it's difficult to get that bit right and how to do it right. We've never really discussed - (Ivan, University E).

If writing practices are not made visible in the engineering curriculum it becomes difficult for them to be developed, because subject coordinators will not be aware of what types and levels of writing students have practised in preceding and subsequent subjects. As Ivan points out, it is likely that students do the same type of writing (“level one, level one”) until their final year when they are expected to write an honours thesis. While this is regarded as problematic by the participants, few solutions are offered. In contrast, subject coordinators have a clear knowledge of what propositional knowledge is covered in the subjects that precede and follow their subjects. Propositional knowledge is less contested, more easily trackable, more easily measured, and for the engineers, more easily understood than the slippery, messy and often emotional process that is writing.

Several participants, including Adam and Ivan, often refer to the importance of writing for engineers, but do not acknowledge the learning of writing in the space of their subjects. This could be an example of doublethink: writing is important until it competes for air time with propositional knowledge. Writing is important for engineers but it is not modelled or taught by subject coordinators, unlike the way that the propositional knowledge is modelled, taught and practised. This of course raises the question of how writing can be developed if it is not practised.

Examples of good practices in the development of writing from this study do exist: Damien’s subject is one of these and is discussed in detail in Goldsmith and Willey (2015). Briefly, report writing is scaffolded in Damien’s subject (University B), and is developed throughout the major in which his subject is situated. In his subject students write two field reports; the first (preliminary) report is given formative feedback which can then be used for the second report. On Damien’s own admission, scaffolding was introduced because the ALL lecturer at his university suggested it. Although writing practices are developed in Damien’s school of engineering, they are very narrowly defined; he refers to writing only in the context of report writing skills. There is no broader interpretation of what else student engineers might write and why.

One participant who sees writing as both developmental and as less constrained than report writing is Bernice:

> … I think there's a strong link between writing and thinking so to get the students to actually write something down they have to have thought about it beforehand. You can punch numbers into a calculator without thinking about it very much and get a number out and write that number down but what I want to see is some thinking, some critical thinking about why did I do that, what does that number and what am I going to do with it now or what's someone else going to do with it now? (Bernice, University A).

Bernice displays a deep understanding about the role of writing in learning; she refers to genres of writing and can distinguish between surface features of writing such as the mechanics of writing (which she explains as grammar, spelling and accurate referencing) and rhetorical features. Where did she come from? Why does she know this and the others don't? She teaches a technical subject, like all the other participants; she has industry experience, like most of the other participants. Yet she has developed a nuanced and thoughtful approach to integrating writing in her subject which is absent in other participants' subjects, and she is aware of gaps in the development of writing within her faculty.

4.3. What do engineering academics understand by the term 'writing practices'?

The insights from Bernice point to one other major contradiction: the slippage of terms about writing. Although I [RG] as interviewer never used the word "English" in any of the interviews, many of the participants did. In fact a range of terms was used by the participants to talk about writing, such as: English; communication; understanding; presenting information; and reporting. This confusion of terms reflects confusion about the role and nature of writing practices in the engineering curriculum, and can be seen in the wording of assessment tasks and of criteria for assessing written assignments. Closer examination shows the range of meanings associated with 'English': English as English language proficiency; English as grammar; English as language; English studied as a subject in high school, as the ability to analyse literary texts, as expression, as clear communication.

If engineering academics think that writing practices are "English" (either the high school subject or English language proficiency), then it is not so surprising that they say: "It's not my job to teach writing". But they are not being asked to do that; what is expected of all academics teaching at university is to induct their students into their disciplinary discourse and assist students to develop this discourse. Perhaps the lack of clarity about what writing is forms part of the resistance to see development of writing as part of their role as engineering educators and to embed writing in the curriculum.

Ivan presents the most striking example of conflicted perspectives about writing, but others express similar, if milder, reactions, where they somehow recognise how difficult writing is. This recognition tends to occur around their own writing, less so around students' writing: "There were times in my life where writing was just almost impossible. But you climb over that hill and you develop the skills to be able to string thoughts together and to be able to then put it onto paper" (Harry, University D).

4.4. Writing practices as 'other'

Going back to the question raised earlier, of why writing practices are "other", a number of possible answers are emerging, which also connect to the invisibility of writing practices. They are "other" because they are seen as a separate thing: separate from the technical content, separate from the calculations, separate from the image of an engineer (think of the ubiquitous hard hat and/or lab coat). It is intriguing to think about where this separation situates itself. There are many disciplines where the academics would not see themselves as writers, but engineering academics seem more intransigent than most in separating or keeping separate the practices of writing from the practices of engineering. One facet of this is the location of writing (as part of communication) in the domain of generic attributes in Australian and international engineering faculties, as noted by Ivan. Engineers Australia (2013) has "effective oral and written communication in professional and lay domains" as one of its competencies in the personal and professional attributes, which are frequently referred to as "soft" skills. Although prominent engineering educators acknowledge that these skills are both important and challenging to teach (Johnston & McGregor, 2004) it is conceivable that casting such skills as "soft", as opposed to the "hard" skills of technical knowledge, condemns the former to a lower status in the eyes of many engineering academics. Therefore, to be involved in the development of soft skills might make the academic somehow – soft?

5. Conclusions

In this paper we have sought to illustrate how AT can provide a lens through which to view perceptions of writing practices in engineering subjects. As with previous studies such as Orland-Barak and Becher (2011) and Behrend (2014), AT has been used to "zoom out" to provide a wider context, and to "magnify … contradictions" (Orland-Barak & Becher, 2011, p. 127) in these learning environments. Overall, the current findings show that engineering academics have a different view of the value and nature of technical knowledge compared to their view of value and nature of writing practices, consequently leading to tensions and contradictions in practices. Many also have only a partial understanding of writing practices. One possible explanation for the tensions and contradictions demonstrated by participants such as Ivan could be that they are experiencing a clash of activity systems. That is, trying to get the students to care about writing is a different kind of activity system that conflicts with the activity systems of the majority of engineering academics; those who practise a 'traditional' mode of teaching engineering where writing is not considered part of the responsibility of the lecturer.

It is likely that further themes and tensions will emerge as this study continues. The analysis to date has revealed that there are obvious tensions between engineering academics' perspectives of propositional knowledge and of writing practices within their subjects, leading to the conclusion that they see writing as a different kind of knowledge, or a different kind of knowing. While this is no surprise to Academic Language and Learning lecturers working with staff in STEM disciplines, it is important to conduct further research in this area to support our anecdotal evidence. We will continue to explore this avenue in depth. For the moment, consideration needs to be given to the impact of the individual subject coordinators on such an integral aspect of engineering education and engineering practice as writing. Currently, if an engineering subject coordinator decides that it is not their job to teach (provide opportunities to practise, develop, model) writing, that is their prerogative. There is nothing to prevent 100% of engineering subject coordinators from making that decision. It should not be up to the "Bernices" and "Damiens" of engineering education to shoulder the responsibility of providing students with opportunities to practise and develop their writing, and to help students understand the complex roles that writing plays in academia, in work, and in society. Engineering faculties need to adopt top down and grassroots strategies to ensure that students can write proficiently in their disciplines and in their jobs, for diverse purposes and audiences. Findings such as these can be used to develop a discussion with engineering academics to emphasise the developmental nature of writing and to make writing practices more visible and more integral to the engineering curriculum. If changes do not occur, there is a strong risk that engineering graduates will continue to enter the workplace with inadequate abilities to discuss, argue, reason, evaluate and communicate, with all the limitations that this implies for society.

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References

Accreditation Board for Engineering and Technology [ABET]. (2011). *Criteria for accrediting engineering programs*. Baltimore MD: ABET.

Behrend, M. (2014). Engestrom's activity theory as a tool to analyse online resources embedding academic literacies. *Journal of Academic Language & Learning*, *8*(1), A109-A120.

Blakeslee, A.M. (1997). Activity, context, interaction and authority: Learning to write scientific papers in situ. *Journal of Business and Technical Communication*, *11*(2), 125-169.

Carter, M. Ferzli, M., & Wiebe, E. (2007).Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*, *21*, 278.

Curry, M.J. (2014). Graphics and invention in engineers' writing for publication. In M.J. Curry & D.I. Hanauer (Eds.), *Language, literacy and learning in STEM education* (pp.87-106), Amsterdam: John Benjamins Publishing Company.

Dias, P., Freedman, A., Medway, P., & Pare`, A., (1999). *Worlds Apart: Acting and writing in academic and workplace contexts*. Mahwah NJ: Lawrence Erlbaum Associates.

Engestrom, Y. (2001). Expansive learning at work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, *14*(1), 133-156.

Engineers Australia. (2013). *Stage 1 competency standard for professional engineers*. Retreieved from https://www.engineersaustralia.org.au/sites/default/files/shado/Education/Program%20Accreditation/130607_stage_1_pe_2013_approved.pdf

Goldsmith, R., & Willey, K. (2015). Activity theory analysis of the visibility of writing practices in the engineering curriculum. *Proceedings of the 6th Research in Engineering Education Symposium*, Dublin, Ireland, 13-15 July 2015.

Herrington, A.J. (1985). Writing in academic settings: A study of the contexts for writing in two college chemical engineering courses. *Research in the Teaching of English*, *19*(4), 331-361.

Hilgers, T.L., Hussey, E., & Stitt-Bergh, M. (1999). "As you're writing, you have these epiphanies": What college students say about writing and learning in their majors. *Written Communication*, *16*, 317-353.

Johnston, S., & McGregor, H. (2004). Recognising and supporting a scholarship of practice: Soft skills are hard! *Proceedings of the 15th AAEE Conference*, Toowoomba, Australia, 27-29 September 2004.

Jonassen, D.H., & Rohrer-Murphy, L. (1999). Activity Theory as a framework for designing constructivist learning environments, *Educational Technology Research and Development*, *47*(1), 61-79.

King, R. (2008). Engineers for the Future: addressing the supply and quality of Australian graduates for the 21st Century, ALTC. Retrieved from http://www.olt.gov.au

Koutsantoni, D. (2007). *Developing academic literacies: Understanding disciplinary communities' culture and rhetoric*. Bern, Switzerland: Peter Lang.

Lea, M.R., & Street, B.V. (1998). Student writing in higher education: An academic literacies approach. *Studies in Higher Education*, *23*(2), 157-172.

Lord, S.M. (2009). Integrating effective 'writing to communicate' experiences in engineering courses: Guidelines and examples. *International Journal of Engineering Education*, *25*(1), 196-204.

Mort, P., & Drury, H. (2012). Supporting student academic literacy in the disciplines using genre-based online pedagogy. *Journal of Academic Language and Learning*, *6*(3), A1-A15.

Orland-Barak, L., & Becher, A. (2011). Cycles of action through systems of activity: Examining an action research model through the lens of activity theory. *Mind, Culture, and Activity*,*18*(2), 115-128.

Pflueger, R., Weissbach, R., & Gallagher, S. (2015). Strengthening technical writing knowledge transfer through targeted study in a first-year composition course. *Proceedings of the Research in Engineering Education Symposium*, Dublin, 13-15 July 2015.

Royal Academy of Engineers. (2007). *Educating engineers for the 21st century*. London: Royal Academy of Engineers.

Russell, D. R., & Yañez, A. (2003). Big picture people rarely become historians: Genre systems and the contradictions of general education. In C. Bazerman & D. Russell (Eds.), *Writing Selves/Writing Societies*. Retrieved from http://wac.colostate.edu/books/selves_societies/

Sheppard, S., Macatanga, K., Colby, A. & Sullivan, W.M. (2009). *Educating Engineers- Designing for the Future of the Field*, San Francisco: Jossey-Bass.

Swales, J. (1990). *Genre Analysis*. Cambridge: Cambridge University Press.

Turner, J. (2011). *Language in the Academy*. Bristol: Multilingual Matters.

Watt. R. (2011). Concordance. Retrieved from http://www.concordancesoftware.co.uk/

Wheeler, E., & McDonald, R.L. (2000). Writing in engineering courses, *Journal of Engineering Education*, October 2000, 481-486.

Winsor, D.A. (1990). Engineering writing/writing engineering. *College Composition and Communication*, *41*(1), 58-70.

Winsor, D.A. (1996). *Writing Like an Engineer: A Rhetorical education*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

WRiSE (2012). Retrieved July 31, 2015, from http://www.usyd.edu.au/learningcentre/wrise/

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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. <u>The submissions must be made in a proper folder so that the pages will not be missing (no stapling allowed!!!)</u> [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.

References

ASEE. (2009). *Creating a culture for scholarly and systematic innovation in engineering education.* Phase 1 report. Washington DC: ASEE

Biggs, J. & Tang, C. (2007). *Teaching for quality learning at university*. Maidenhead: Society for Research into Higher Education & Open University Press.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher* Jan-Feb 1989, 32-42

Carter, M., Ferzli, M., & Wiebe, E. (2007). Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*, 21(3), 278-302.

Goldsmith, R., Reidsema, C., Beck, H., & Campbell, D. (2010). Perspectives on teaching and learning in engineering design across four universities. *Proceedings of the 2nd Connect-Ed International Conference on Design Education,* 28 June – 1 July, University of New South Wales, Sydney.

Goldsmith, R., Reidsema, C., & Campbell, D. (2010). Best practice or business as usual? *Proceedings of the Australasian Association of Engineering Education Conference*, 5-8 December 2010, UTS, Sydney.

Herrington, A.J. (1985). Writing in academic settings: A study of the contexts for writing in two college chemical engineering courses. *Research in the Teaching of English,* 19(4), 331-361

Hilgers, T.L., Hussey, E. & Stitt-Bergh, M. (1999). "As you're writing, you have these epiphanies": What college students say about writing and learning in their majors. *Written Communication,* 16, 317-353

iWrite. (2012). http://iwrite.sydney.edu.au/home.htm

Jenkins, S., Jordan, M.K., & Welland, P.O. (1993). The role of writing in graduate engineering education: A survey of faculty beliefs and practices. *English for Specific Purposes,* 12, 51-67

Johnston, S., Lee, A. & McGregor, H. (1996). Engineering as captive discourse. *Society for Philosophy and Technology*, 1(3).

King, R. (2008). *Engineers for the Future: addressing the supply and quality of Australian graduates for the 21st Century.* ALTC, http://www.olt.gov.au

Lave, J. & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation.* Cambridge.Cambridge University Press.

Lea, M.R., & Street,B.V. (1998). Student writing in higher education: An academic literacies approach. *Studies in Higher Education.* 23(2), 157-172.

Lord, S.M. (2009). Integrating effective 'writing to communicate' experiences in engineering courses: Guidelines and examples. *International Journal of Engineering Education,*25(1), 196-204.

Nightingale, S., Carew, A., & Fung, J. (2007). Application of constructive alignment principles to engineering education: Have we really changed? *Proceedings of the Australasian Association of Engineering Education Conference,* 9-13 December 2007, University of Melbourne, Melbourne.

Oehlers, D. & Walker, D. (2006). Assessment of deep learning ability for problems solvers. *International Journal of Engineering Education,* 22(6), 1261-1268.

Male, S.A., Bush, M.B., & Chapman, E. (2009). Identification of competencies required by engineers graduating in Australia. *20th Australasian Association for Engineering Education Conference*, Adelaide, Australia, 882-887

Male, S.A., Bush, M.B., Chapman, E.S. (2011). An Australian study of generic competencies required by engineers. *European Journal of Engineering Education*, 36, 2.

Maton, K. (2000). Recovering pedagogic discourse: A Bernsteinian approach to the sociology of educational knowledge. *Linguistics and Education*, 11(1), 79-88.

Radcliffe, D.F. (2006). Shaping the discipline of engineering education. *Journal of Engineering Education,* October 2006, 95(4), 263-264.

Royal Academy of Engineers. (2007). *Educating engineers for the 21st century.* London: Royal Academy of Engineers

Samuelowicz, K., & Bain, J.D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education,* 41, 299-325.

Sheppard, S., Macatanga, K., Colby, A., & Sullivan, W.M. (2009). *Educating Engineers- Designing for the Future of the Field.* San Francisco: Jossey-Bass

Trevelyan, J. (2007). Technical coordination in engineering practice. *Journal of Engineering Education, 96(3),*191-204.

Walther, J., & Radcliffe, D.F. (2007). The competence dilemma: moving beyond simple graduate attribute mapping. *Australasian Journal of Engineering Education.* 13(1), 41-51.

Wheeler, E., & McDonald, R.L. (2000). Writing in Engineering Courses. *Journal of Engineering Education,* October, 481-486.

Winsor, D.A. (1990). Engineering Writing/writing engineering. *College Composition and Communication,* 41(1), 58-70.

WRiSE. (2011). http://www.usyd.edu.au/learningcentre/wrise/home.html

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References

Accreditation Board for Engineering and Technology (ABET) 2016, *Criteria for accrediting engineering programs*, Baltimore, MD, viewed 10 October 2017, <http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2016-2017>.

American Society for Engineering Education (ASEE) 2009, *Creating a culture for scholarly and systematic innovation in engineering education, Phase 1 report*, ASEE, Washington, DC.

Appleby, Y., Roberts, S., Barnes, L., Qualter, P. & Tariq, V. 2012, 'Who wants to be able to do references properly and be unemployed? STEM student writing and employer needs', *Journal of Learning Development in Higher Education*, special ed., pp. 1-19.

Arkoudis, S. & Starfield, S. 2007, 'In-course language development and support', paper presented to the *National Symposium: English Language Competence of International Students*, Sydney, 14 August, viewed 20 January 2018, <http://aei.dest.gov.au/aei/shop/products/publications/publication624>.

Artemeva, N. 2009, 'Stories of becoming: a study of novice engineers learning genres of their profession', in A.B.C. Bazerman & D. Figueiredo (eds), *Genre in a changing world*, WAC Clearinghouse, Fort Collins, CO, pp. 158-178.

Artemeva, N. 2011, ''An engrained part of my career': the formation of a knowledge worker in the dual space of engineering knowledge and rhetorical process', in A.P.D. Starke-Meyerring, N. Artemeva, M. Horne & L. Yousoubova (eds), *Writing in knowledge societies. Perspectives on writing*, WAC Clearinghouse and Parlor Press, Fort Collins, CO, pp. 321-50.

Bandura, A. 2001, 'Social cognitive theory: an agentic perspective', *Annual Review of Psychology*, vol. 52, pp. 1-26.

Barnhill, D. 2010, *Otherness and anotherness*, University of Wisconsin Oshkosh, viewed 12 January 2018, <http://www.uwosh.edu/facstaff/barnhill/490-docs/thinking/other>.

Bazerman, C. 1988, *Shaping written knowledge*, University of Wisconsin, Madison, WI.

Beer, D.F. 2002, 'Reflections on why engineering students don't like to write – and what we can do about it', paper presented to the *IEEE International Professional Communication Conference*, Portland, OR, 20 September.

Behrend, M. 2014, 'Engeström's activity theory as a tool to analyse online resources embedding academic literacies', *Journal of Academic Language & Learning*, vol. 8, no. 1, pp. A109-20.

Bernstein, B. 2000, *Pedagogy, symbolic control, and identity: theory, research, critique,* Rowman & Littlefield, Lanham, MD.

Bernstein, T. 1971, *Miss Thistlebottom's hobgoblins*, Farrar, Straus and Giroux, New York, NY.

Beswick, D. & Ramsden, P. 1987, *How to promote learning with understanding*, Centre for Study of Higher Education, University of Melbourne, Melbourne.

Bhabha, H.K. 1983, 'The other question …', *Screen*, vol. 24, no. 6, pp. 18-36.

Biggs, J. & Tang, C. 2007, *Teaching for quality learning at university*, Society for Research into Higher Education & Open University Press, Maidenhead.

Blackler, F. & Regan, S. 2009, 'Intentionality, agency, change: practice theory and management', *Management Learning*, vol. 40, no. 2, pp. 161-76.

Blakeslee, A.M. 1997, 'Activity, context, interaction and authority: learning to write scientific papers in situ', *Journal of Business and Technical Communication*, vol. 11, no. 2, pp. 125-69.

Blommaert, J. 2007, 'On scope and depth in linguistic ethnography', *Journal of Sociolinguistics*, vol. 11, no. 5, pp. 682-8.

Boud, D. 1993, 'Experience as the base for learning', *Higher Education Research and Development*, vol. 12, no. 1, pp. 33-44.

Boud, D. 1995, 'Assessment and learning: contradictory or complementary?', in P. Knight (ed.), *Assessment for learning in higher education*, Routledge Falmer, London, pp. 35-48.

Boud, D. & Brew, A. 2017, 'Learning to teach as the development of practice,' in B. Leibowitz, V. Bozalek & P. Kahn (eds), *Theorising learning to teach in higher education: sociomaterial, social practice and realist approaches*, Routledge, London, pp. 77-92.

Braine, G. 1989, ‘Writing in science and technology: an analysis of assignments from ten undergraduate courses’, *English for Specific Purposes*, vol. 8, pp. 3-15.

Brons, L. 2015, ‘Othering, an analysis’, *Transcience*, vol. 6, no. 1, pp. 69-90.

Brown, B.A., Reveles, J.M. & Kelly, G.J. 2005, ‘Scientific literacy and discursive identity: a theoretical framework for understanding science learning’, *Science Education: Issues and Trends*, vol. 89, no, 5, pp. 779-802.

Brown, J.S., Collins, A. & Duguid, P. 1989, ‘Situated cognition and the culture of learning’, *Educational Researcher*, vol. 18, no. 1, pp. 32-42.

Buch, A. & Andersen, V. 2015, ‘Team and project work in engineering practices’, *Nordic Journal of Working Life Studies*, vol. 5, no. 3a, pp. 27-46.

Bury, S. & Sheese, R. 2016, ‘Academic literacies as cornerstones in course design: a partnership to develop programming for faculty and teaching assistants’, *Journal of University Teaching & Learning Practice*, vol. 13, no. 3, pp. 1-20.

Cameron, I., Reidsema, C. & Hadgraft, R. 2011, ‘Australian engineering academe: a snapshot of demographics and attitudes’, paper presented to the *22nd Annual Conference for the Australasian Association for Engineering Education (AAEE): Developing Engineers for Social Justice: Community Involvement, Ethics & Sustainability*, Fremantle, 5-7 December.

Carter, M., Ferzli, M. & Wiebe, E. 2007, ‘Writing to learn by learning to write in the disciplines’, *Journal of Business and Technical Communication*, vol. 21, pp. 278-302.

Colman, B. & Willmot, P. 2016, ‘How soft are ‘soft skills’ in the engineering profession?’, paper presented to the *44th SEFI Conference*, Tampere, Finland, 12-15 September.

Colorado State University 2017, *Writing collections*, viewed 7 December 2017, <https://writing.colostate.edu/collections>.

Crawley, E.F., Malmqvist, J., Östlund, S. & Brodeur, D.R. 2007, *Rethinking Engineering Education: The CDIO Approach*, Springer, New York.

Creese, A. 2008, ‘Linguistic ethnography,’ in H.N. Hornberger (ed.), *Encyclopedia of language and education*, *vol. 10: Research methods in language and education*, 2nd edn, pp. 229-41.

Creswell, J.W., Hanson, W.E., Plano Clark, V.L. & Morales, A. 2007, ‘Qualitative research designs: selection and implementation’, *The Counseling Psychologist*, vol. 35, no. 2, pp. 236-64.

Curry, M.J. 2014, ‘Graphics and invention in engineers’ writing for publication’, in M.J. Curry & D.I. Hanauer (eds), *Language, literacy and learning in STEM education*, John Benjamins, Amsterdam, pp. 87-106.

Curry, M.J. & Lillis, T. 2003, ‘Issues in academic writing in higher education’, in C. Coffin, M.J. Curry, S. Goodman, A. Hewings, T. Lillis & J. Swann (eds), *Teaching academic writing: a toolkit for higher education*, Routledge, New York, NY, pp. 1-18.

Deakin Crick, R., Huang, S., Ahmed Shafi, A. & Goldspink, C. 2015, 'Developing Resilient Agency in Learning: The Internal Structure of Learning Power', *British Journal of Educational Studies*, vol. 63, no. 2, pp. 121-60.

Denzin, N.K. & Lincoln, Y.S. 2000, ‘Introduction: the discipline and practice of qualitative research’, in N.K. Denzin & Y.S. Lincoln (eds), *Handbook of qualitative research*, Sage, Thousand Oaks, CA, pp. 1-28.

De Paola, M. & Gioia, F. 2012, ‘Risk aversion and field of study choice: the role of individual ability’, *Bulletin of Economic Research*, vol. 64, no. 1, pp. 193-208.

Department of Education, Employment and Workplace Relations 2009, *Good practice principles for English language proficiency for international students in Australian universities: final report*, Department of Education, Employment and Workplace Relations, Canberra, viewed 23 November 2012, http://pandora.nla.gov.au/pan/99582/20090518-1113/www.deewr.gov.au/HigherEducation/Publications/Pages/FinalReport.pdf

Dias, P., Freedman, A., Medway, P. & Pare, A. 1999, *Worlds apart: acting and writing in academic and workplace contexts*, Lawrence Erlbaum, Mahwah, NJ.

Downey, G. & Lucena, J. 2003, ‘When students resist: ethnography of a senior design experience in engineering education’, *International Journal of Engineering Education*, vol.19, no. 1, pp. 168-176.

Duderstadt, J.J. 2008, *Engineering for a changing world*, University of Michigan, Ann Arbor, MI.

Dym, C., Agogino, A., Eris, O., Frey, D. & Leifer, L. 2005, 'Engineering design thinking, teaching and learning', *Journal of Engineering Education*, vol. 94, no. 1, pp. 103-20.

Edwards, A. 2001, 'Researching pedagogy: a sociocultural agenda', *Pedagogy, Culture & Society*, vol. 9, no. 2, pp. 161-86.

Edwards-Groves, C. & Stephen, K. 2015, 'Pedagogy, education and praxis: understanding new forms of intersubjectivity through action research and practice theory', *Educational Action Research*, vol. 24, no. 1, pp. 77-96.

Eisenhardt, K. 1989, 'Building theories from case study research', *Academy of Management Review*, vol. 14, no. 4, pp. 532-50.

Engeström, Y. 2001, 'Expansive learning at work: toward an activity theoretical reconceptualization', *Journal of Education and Work*, vol. 14, no. 1, pp. 133-56.

Engineering Council 2014, *The accreditation of higher degree programs,* 3rd edn, viewed 11 March 2015, <http://www.engc.org.uk/engcdocuments/internet/Website/Accreditation%20of%20Higher%20Education%20Programmes%20third%20edition%20%281%29.pdf>.

Engineers Australia 2009, *National Curriculum Board Submission in response to the National Mathematics and Science Curriculum Framing Papers*, Engineers Australia, Barton ACT.

Engineers Australia 2013, *Stage 1 competency standard for professional engineers,* <*https://www.engineersaustralia.org.au/sites/default/files/resource-files/2017-03/Stage%201%20Competency%20Standards.pdf>.*

Evans, D. & Gruba, P. 2007, *How to write a better thesis*, 2nd edn, Melbourne University Press, Carlton.

Faulkner, B.E. & Herman, G.L. 2016, 'Espoused faculty epistemologies for engineering mathematics: towards defining 'mathematical maturity' for engineering', *Proceedings of the 2016 American Society for Engineering Education Annual Conference and Exposition*, New Orleans, LA, June 26-29, pp. 1-11.

Faulkner, W. 2007, ''Nuts and bolts and people': gender-troubled engineering identities', *Social Studies of Science*, vol. 37, no. 3, pp. 331-56.

Fenton-Smith, B. & Gurney, L. 2016, 'Actors and agency in academic language policy and planning', *Current Issues in Language Planning*, vol. 17, no. 1, pp. 72-87.

Fischer, A. 2015, ‘‘Hidden features’ and ‘overt instruction’ in academic literacy practices: a case study in engineering’, in K.H.T. Lillis, M.R. Lea & S. Mitchell (eds), *Working with academic literacies*, WAC Clearinghouse, Fort Collins, CO, pp. 75-85.

Gardner, A., Goldsmith, R. & Vessalas, K. 2016, ‘Using practice architectures theory to compare consecutive offerings of the same subject’, paper presented to the *2016 Australasian Association of Engineering Education Conference*, Coffs Harbour, NSW, 4-7 December.

Garland, J., Duerden, S., Helfers, C. & Evans, D.L. 1999, ‘Teaching engineering students their own discourse’, paper presented to the *29th ASEE/IEEE Frontiers in Education Conference*, San Juan, Puerto Rico, 10-13 November.

Gee, J.P. 1999, ‘Identity as an analytic lens for research in education’, *Review of Research in Education*, vol. 25, pp. 99-125.

Gee, J.P. 2001, ‘Quality, science and the lifeworld’, in P. Freebody, S. Muspratt & B. Dwyer (eds), *Difference, silence and textual practice*, Hampton Press, Cresskill, NJ, pp. 359-82.

Geirsdottir, G. 2011, ‘Teachers’ conceptions of knowledge structures and pedagogic practices in higher education’, in G. Ivinson, B. Davies & J. Fitz (eds), *Knowledge and identity: concepts and applications in Bernstein’s sociology*, Routledge, Abingdon, pp. 90-106.

Gill, P., Stewart, K., Treasure, E. & Chadwick, B. 2008, ‘Methods of data collection in qualitative research: interviews and focus groups’, *British Dental Journal*, vol. 204, no. 6, pp. 291-5.

Gimenez, J. 2014, ‘Writing as social practice in engineering: views from a cross-disciplinary study’, in M.J. Curry & D.I. Hanauer (eds), *Language, literacy and learning in STEM education*, John Benjamins, Amsterdam, pp. 67-86.

Gimenez, J. & Thondhlana, J. 2012, ‘Collaborative writing in engineering: perspectives from research and implications for undergraduate education’, *European Journal of Engineering Education*, vol. 37, no. 5, pp. 471-87.

Gist, M.E. & Mitchell, T.R. 1992, ‘Self-efficacy: a theoretical analysis of its determinants and malleability’, *Academy of Management Review*, vol. 17, no. 2, pp. 183-211.

Godfrey, E. 2009, ‘Exploring the culture of engineering education: the journey’, *Australasian Journal of Engineering Education*, vol. 15, no. 1, pp. 1-12.

Godfrey, E. & Parker, L. 2010, ‘Mapping the cultural landscape in engineering education’, *Journal of Engineering Education*, vol. 99, no. 1, pp. 5–22.

Goldberg, D. 2011, *The big beacon manifesto*, viewed 25 August 2013, <http://bigbeacon.org/big-beacon-manifesto.pdf>.

Goldsmith, R., Reidsema, C., Beck, H. & Campbell, D.A. 2010, ‘Perspectives on teaching and learning in engineering design across four universities’, paper presented to the *ConnectED 2010 – 2nd International Conference on Design Education*, UNSW, Sydney, 28 June-1 July.

Goldsmith, R., Reidsema, C. & Campbell, D.A. 2010, ‘Best practice or business as usual?’, paper presented to the *21st Australasian Association of Engineering Education Conference*, University of Technology Sydney, Sydney, 5-8 December.

Goldsmith, R., Reidsema, C., Campbell, D.A., Hadgraft, R. & Levy, D. 2010, ‘Designing the future’, *Australasian Journal of Engineering Education*, vol. 16, no. 2, pp. 1-9.

Goldsmith, R. & Willey, K. 2014, ‘Invisible writing (practices) in the engineering curriculum?’, paper presented to the *Australasian Association of Engineering Education Conference Wellington*, Wellington, 8-10 December.

Goldsmith, R. & Willey, K. 2015, ‘Activity theory analysis of the visibility of writing practices in the engineering curriculum’, paper presented to the *6th Research in Engineering Education Symposium*, Dublin, 13-15 July.

Goldsmith, R. & Willey, K. 2016a, ‘How can the development of writing practices in the engineering curriculum be enabled?’, paper presented to the *AAEE 2016 Conference*, Coffs Harbour, NSW, 4-6 December.

Goldsmith, R. & Willey, K. 2016b, ‘‘It’s not my job to teach writing’: activity theory analysis of [invisible] writing practices in the engineering curriculum’, *Journal of Academic Language & Learning*, vol. 10, no. 1, pp. A118-29.

Goldsmith, R. & Willey, K. 2017, ‘Using practice architectures to investigate the invisibility of writing practices in the engineering curriculum’, paper presented to the *Frontiers in Education Conference*, Indianapolis, IN, 18-21 October.

Goldsmith, R. & Willey, K. 2018, ‘The otherness of writing in the engineering curriculum: a practice architectures theory perspective’, *Journal of Academic Language & Learning*, vol. 12, no. 1, pp. 97-114.

Goldsmith, R., Willey, K. & Boud, D. 2012, 'How can writing develop students’ deep approaches to learning in the engineering curriculum? ', paper presented to the *AAEE 2012 Conference,* Melbourne, Victoria, 3-5 December.

Goldsmith, R., Willey, K. & Boud, D. 2017, ‘Investigating invisible writing practices in the engineering curriculum using practice architectures’, *European Journal of Engineering Education*, published online 16 November 2017.

Goodhew, P. 2010, *Teaching engineering: all you need to know about engineering education but were afraid to ask*, The Higher Education Academy, Liverpool, UK.

Goodyear, V.A., Casey, A. & Kirk, D. 2016, ‘Practice architectures and sustainable curriculum renewal’, *Journal of Curriculum Studies*, vol. 49, no. 2, pp. 235-254.

Green, B. 2009, ‘The primacy of practice and the problem of representation’, in B. Green (ed.), *Understanding and researching professional practice*, Sense Publishers, Amsterdam, pp. 39-54.

Hacker, S. 1989, *Pleasure, power and technology: some tales of gender, engineering, and the cooperative workplace*, Unwin Hyman, Winchester, MA.

Halliday, M.A.K. & Martin, J.R. 1993, *Writing science: literacy and discursive power*, University of Pittsburgh Press, Pittsburgh, PA.

Hardy, I. 2010, ‘Academic architectures: academic perceptions of teaching conditions in an Australian university’, *Studies in Higher Education*, vol. 35, no. 4, pp. 391-404.

Hasan, R. 1999, ‘The disempowerment game: Bourdieu and language in literacy’, *Linguistics and Education*, vol. 10, no. 1, pp. 25-87.

Heffernan, M. 2011, *Willful blindness: why we ignore the obvious at our peril*, Walker & Company, New York, NY.

Herrington, A.J. 1985, ‘Writing in academic settings: a study of the contexts for writing in two college chemical engineering courses’, *Research in the Teaching of English*, vol. 19, no. 4, pp. 331-61.

Hilgers, T.L., Hussey, E. & Stitt-Bergh, M. 1999, ‘‘As you’re writing, you have these epiphanies’: what college students say about writing and learning in their majors’, *Written Communication*, vol. 16, pp. 317-53.

Hood, S. 2010, ‘Writing discipline: comparing inscriptions of knowledge and knowers in academic writing’, in F. Christie & K. Maton (eds), *Disciplinarity: functional linguistic and sociological perspectives*, Continuum, London.

Howard, S., Khosronejad, M. & Calvo, R. 2016, ‘Exploring engineering instructors’ views about writing and online tools to support communication in engineering’, *European Journal of Engineering Education,* vol.42, no.6, pp. 875-889. <https://writing.colostate.edu/collections/collection.cfm?collectioncategory_active=36>.

Howard, S. & Maton, K. 2011, ‘Theorising knowledge practices: a missing piece of the educational technology puzzle’, *Research in Learning Technology*, vol. 19, no. 3, pp. 191-206.

International Engineering Alliance 2014, *25 Years of the Washington Accord*, International Engineering Alliance, Wellington, NZ.

Ivanic, R. 2004, ‘Discourses of writing and learning to write’, *Language and Education*, vol. 18, no. 3, pp. 220-45.

Jackson, F. 2016, ‘Unraveling high school English literature pedagogic practices: a legitimation code theory analysis’, *Language and Education*, vol. 30, no. 6, pp. 536-53.

Jenkins, S., Jordan, M.K. & Weiland, P.O. 1993, ‘The role of writing in graduate engineering education: a survey of faculty beliefs and practices’, *English for Specific Purposes*, vol. 12, pp. 51-67.

Johan, M. 2009, ‘Forms of knowledge and curriculum coherence’, *Journal of Education and Work*, vol. 22, no. 3, pp. 205-26.

Johnston, S. &McGregor, H. 2004, ‘Recognising and supporting a scholarship of practice: soft skills are hard!’, paper presented to the *15th AAEE Conference*, Toowoomba, Qld, 27-29 September.

Johnston, S., Lee, A. & McGregor, H. 1996, ‘Engineering as captive discourse’, *Techne: Research in Philosophy and Technology*, vol. 1, no. 3, pp. 128-136.

Jonassen, D.H. & Rohrer-Murphy, L. 1999, ‘Activity theory as a framework for designing constructivist learning environments’, *Educational Technology Research & Development*, vol. 47, no. 1, pp. 61-79.

Joordens, M., Chandrasekaran, S., Stojcevski, A. & Littlefair, G. 2012, ‘The process of design based learning: a students’ perspective’, paper presented to the *23rd Annual Conference of the Australasian Association for Engineering Education 2012*, Melbourne, 3-5 December.

Kember, D. & Kwan, P.K. 2000, ‘Lecturers’ approaches to teaching and their relationship to conceptions of good teaching’, *Instructional Science*, vol. 28, pp. 469-90.

Kemmis, S. 2009, ‘Understanding professional practice: a synoptic framework’, in B. Green (ed.), *Understanding and researching professional practice*, Sense Publishers, Rotterdam, pp. 19-38.

Kemmis, S. 2012, ‘Researching educational praxis: spectator and participant perspectives’, *British Educational Research Journal*, vol. 38, no. 6, pp. 885–905.

Kemmis, S. 2013, *The theories of practice architectures and ecologies of practices,* Presentation at Tromsø University, 4 November, Tromsø.

Kemmis, S., Edwards-Groves, C., Wilkinson, J. & Hardy, I. 2012, ‘Ecologies of practices’, in P. Hager, A. Lee & A. Reich (eds), *Practice, learning and change*, Springer, Dordrecht, pp. 33-50.

Kemmis, S. & Grootenboer, P. 2008, ‘Situating praxis in practice: practice architectures and the cultural, social and material conditions for practice’, in S. Kemmis & T.J. Smith (eds), *Enabling praxis: challenges for education*, Sense, Rotterdam, pp. 37-62.

Kemmis, S. & Mutton, R. 2012, ‘Education for sustainability (EfS): practice and practice architectures’, *Environmental Education Research*, vol. 18, no. 2, pp. 187-207.

Kemmis, S., Wilkinson, J. & Edwards-Groves, C. 2017, ‘Roads not travelled, roads ahead: how the theory of practice architectures is travelling’, in K. Mahon, S. Francisco & S. Kemmis (eds), *Exploring education and professional practice through the lens of practice architectures*, Springer, Singapore, pp. 239-56.

Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L. 2014, *Changing practices, changing education*, Springer, Singapore.

King, R. 2008, *Engineers for the future: addressing the supply and quality of Australian graduates for the 21st century*, Office of Learning and Teaching, Australian Government, Strawberry Hills, NSW.

Koutsantoni, D. 2007, *Developing academic literacies: understanding disciplinary communities' culture and rhetoric*, vol. 4, Peter Lang, Bern.

Kranov, A.A. 2009, 'It's not my job to teach them how to write': facilitating the disciplinary rhetorical socialization of international ESL graduate assistants in the sciences and engineering', paper presented to the *ASEE 2009 Annual Conference & Exposition*, Austin, TX, 14-17 June.

Latour, B. & Woolgar, S. 1986, *Laboratory life: the construction of scientific facts*, Princeton University Press, Princeton, NJ.

Lave, J. & Wenger, E. 1991, *Situated learning: legitimate peripheral participation*, Cambridge University Press, Cambridge.

Lea, M.R. & Street, B. 1998, 'Student writing in higher education: an academic literacies approach', *Studies in Higher Education*, vol. 23, no. 2, pp. 157-72.

Lee, A. & Taylor, E. 1996, 'The dilemma of obedience: a feminist perspective on the making of engineers', *Educational Philosophy and Theory*, vol. 28, no. 1, pp. 57-75.

Leydens, J.A. 2008, 'Novice and insider perspectives on academic and workplace writing: toward a continuum of rhetorical awareness', *IEEE Transactions on Professional Communication*, vol. 51, no. 3, pp. 242-63.

Lillis, T. 2001, *Student writing: access, regulation, desire*, Routledge, London.

Lillis, T. 2006, 'Moving towards an 'academic literacies' pedagogy: dialogues of participation', in L. Ganobcsik-Williams (ed.), *Teaching academic writing in UK higher education*, Palgrave Macmillan, Basingstoke, pp. 30-45.

Lillis, T. 2008, 'Ethnography as method, methodology, and 'deep theorizing': closing the gap between text and context in academic writing', *Written Communication*, vol. 25, no. 3, pp. 353-88.

Lillis, T. & Scott, M. 2007, 'Defining academic literacies research: issues of epistemology, ideology and strategy', *Journal of Applied Linguistics*, vol. 4, no. 1, pp. 5-32.

Lillis, T. & Turner, J. 2001, ‘Student writing in higher education: contemporary confusion, traditional concerns’, *Teaching in Higher Education*, vol. 6, no. 1, pp. 57-68.

Lloyd, B., Rice, M., Ferguson, C. & Palmer, S. 2001, *Engineering the future: preparing professional engineers for the 21st century*, Association of Professional Engineers, Scientists and Managers, Australia, Brighton East.

Lord, S.M. 2009, ‘Integrating effective ‘writing to communicate’ experiences in engineering courses: guidelines and examples’, *International Journal of Engineering Education*, vol. 25, no. 1, pp. 196-204.

Lucena, J.C. 2003, ‘Flexible engineers: history, challenges and opportunities for engineering education’, *Bulletin of Science, Technology & Society*, vol. 23, no. 6, pp. 419-35.

Mahon, K. 2014, *Critical pedagogical praxis in higher education*, PhD thesis, Charles Sturt University, Wagga Wagga .

Mahon, K. & Galloway, L. 2017, ‘Provoking praxis amidst a faculty restructure: a practice architecture perspective’, in K. Mahon, S. Francisco & S. Kemmis (eds), *Exploring education and professional practice: through the lens of practice architectures*, Springer, Singapore, pp. 183-99.

Mahon, K., Kemmis, S., Francisco, S. & Lloyd-Zantiotis, A. 2017, ‘Introduction: practice theory and the theory of practice architectures’, in K. Mahon, S. Francisco & S. Kemmis (eds), *Exploring education and professional practice: through the lens of practice architectures*, Springer, Singapore, pp. 1-30.

Male, S.A., Bush, M. & Chapman, E.S. 2009, 'Identification of competencies required by engineers graduating in Australia', paper presented to the *2009 Australasian Association of Engineering Education Conference*, Adelaide, 6-9 December.

Male, S.A., Bush, M. & Chapman, E.S. 2011, ‘An Australian study of generic competencies required by engineers’, *European Journal of Engineering Education*, vol. 36, no. 2, pp. 151-163.

Mallette, J.C. 2017a, ‘Expanding efficiency: women’s communication in engineering’, *Engineering Studies*, vol. 9, no. 3, pp. 195-221.

Mallette, J.C. 2017b, ‘Writing and women’s retention in engineering’, *Journal of Business and Technical Communication*, vol. 31, no. 4, pp. 417-42.

Manidis, M. & Yasukawa, K. 2017, 'Developing professionally: a practice-based perspective', in B. Leibowitz, V. Bozalek & P. Kahn (eds), *Theorising learning to teach in higher education*, Routledge, Abingdon, pp. 93-109.

Martin, J.R. & Maton, K. 2013, 'Cumulative knowledge-building in secondary schooling', *Linguistics and Education*, vol. 24, pp. 1-3.

Maton, K. 2000, 'Recovering pedagogic discourse: a Bernsteinian approach to the sociology of educational knowledge', *Linguistics and Education*, vol. 11, no. 1, pp. 79-88.

Maton, K. 2010, 'Analysing knowledge claims and practices: languages of legitimation', in K. Maton & R. Moore (eds), *Social realism, knowledge and the sociology of education: coalitions of the mind*, Continuum International Publishing Group, London, pp. 35-59.

Maton, K. 2014a, *Knowledge and knowers: towards a realist sociology of education*, Routledge, Abingdon.

Maton, K. 2014b, 'A tall order': legitimation code theory for academic language and learning', Journal of Academic Language and Learning, vol. 8, no, 3, pp. 34-48.

Maton, K. & Chen, R.T.-H. in press, 'Specialization from legitimation code theory: how the basis of achievement shapes student success', in J.R. Martin, K. Maton, P. Wang & Z. Wang (eds), *Understanding academic discourse*, Shanghai Jiao Tong University, Shanghai.

McKenna, B. 1997, 'How engineers write', *Applied Linguistics*, vol. 18, no. 2, pp. 189-211.

Missingham, D. 2006, 'The Integration of Professional Communication Skills into Engineering Education', paper presented to the *EDU-COM 2006 International Conference. Engagement and Empowerment: New Opportunities for Growth in Higher Education*, Edith Cowan University, Perth Western Australia, 22-24 November 2006, <http://ro.ecu.edu.au/ceducom/91>.

Mitchell, S. 2010, 'Now you don't see it, now you do: writing made visible in the university', *Arts and Humanities in Higher Education*, vol. 9, no. 2, pp. 133-48.

Mort, P. & Drury, H. 2012, ‘Supporting student academic literacy in the disciplines using genre-based online pedagogy’, *Journal of Academic Language and Learning*, vol. 6, no. 3, pp. A1-15.

Mort, P., Drury, H., Calvo, R., Skinner, I., McEwan, A., Levy, D., Molina, M.G. & Mitrajit, R. 2012, ‘An online writing centre for engineering students’, paper presented to the *8th International CDIO Conference*, Queensland University of Technology, Brisbane, 1-4 July.

Muller, J. 2009, ‘Forms of knowledge and curriculum coherence’, *Journal of Education and Work*, vol. 22, no. 3, pp. 205-26.

Muller, M. 2008, ‘Reconsidering the concept of discourse for the field of geopolitics: towards discourse as language and practice’, *Political Geography*, vol. 27, pp. 322-38.

Murray, R. 2013, ‘‘It’s not a hobby’: reconceptualizing the place of writing in academic work’, *Higher Education*, vol. 66, no. 1, pp. 79-91.

Nagle, J. 1996, *Handbook for preparing engineering documents*, IEEE Press, New York, NY.

Nicolini, D. 2012, *Practice Theory, Work, & Organization,* Oxford University Press, Oxford.

Nicolini, D. 2017, 'Is small the only beautiful? Making sense of 'large phenomena' from a practice-based perspective', in A. Hui, T. Schatzki & E. Shove (eds), *The nexus of practice: connections, constellations and practitioners,* Routledge, London.

Nightingale, S., Carew, A. & Fung, J. 2007, ‘Application of constructive alignment principles to engineering education: have we really changed?’, paper presented to the *2007 Australasian Association of Engineering Education Conference,* University of Melbourne, Melbourne, 9-13 December.

Norton, A., Sonnemann, J. & Cherastidtham, I. 2013, *Taking university teaching seriously*, Grattan Institute, Carlton, Vic.

Orland-Barak, L. & Becher, A. 2011, ‘Cycles of action through systems of activity: examining an action research model through the lens of activity theory’, *Mind, Culture, and Activity*, vol. 18, no. 2, pp. 115-28.

Orr, T. 1999, ‘Genre in the field of computer science and computer engineering’, *IEEE Transactions on Professional Communication*, vol. 42, no. 1, pp. 32-7.

Paretti, M.C. 2008, ‘Teaching Communication in capstone design: the role of the instructor in situated learning’, *Journal of Engineering Education,* October 2008, pp. 491-308.

Paretti, M. & McNair, L. 2012, ‘Analyzing the intersections of institutional and discourse identities in engineering work at the local level’, *Engineering Studies*, vol. 4, no. 1, pp. 55-78.

Patton, M.Q. 1990, *Qualitative evaluation and research methods*, 2nd edn, Sage, Newbury Park, CA.

Pawley, A. 2009, ‘Universalized narratives’, *Journal of Engineering Education*, vol. 98, no. 4, pp. 309-19.

Pflueger, R., Weissbach, R. & Gallagher, S. 2015, ‘Strengthening technical writing knowledge transfer through targeted study in a first-year composition course’, paper presented to the *Research in Engineering Education Symposium*, Dublin, 13-15 July.

Popik, B. 2012, ‘Four years ago, I couldn’t spell engineer; now I are one’, *The Big Apple*, weblog, viewed 13 January 2017, <http://www.barrypopik.com/index.php/new_york_city/entry/four_years_ago_i_couldnt_spell_engineer_now_i_are_one >.

Reckwitz, A. 2017, ‘Practices and their affects’, in A. Hui, T. Schatzki & E. Shove (eds), *The nexus of practices: connections, constellations, practitioners*, Routledge, Abingdon, pp. 114-25.

Reich, A. & Hager, P. 2014, ‘Problematising practice, learning and change: practice-theory perspectives on professional learning’, *Journal of Workplace Learning*, vol. 26, no. 6/7, pp. 418-31.

Reich, A., Rooney, D., Gardner, A., Willey, K., Boud, D. & Fitzgerald, T. 2015, ‘Engineers’ professional learning: a practice-theory perspective’, *European Journal of Engineering Education*, vol. 40, no. 4, pp. 366-79.

Rooney, D., Boud, D., Reich, A., Fitzgerald, T., Willey, K. & Gardner, A. 2012, ‘Using practice theory to investigate professional engineers’ workplace learning’, paper presented to the *IEEE Frontiers in Education Conference*, Seattle, 3-6 October.

Rooney, D., Gardner, A., Willey, K., Reich, A., Boud, D. & Fitzgerald, T. 2015, 'Reimagining site-walks: sites for rich learning', *Australasian Journal of Engineering Education*, vol. 20, no. 1, pp. 19-30.

Royal Academy of Engineers 2007, *Educating engineers for the 21st century*, Royal Academy of Engineers, London.

Ruff, S. & Carter, M. 2015, 'Characterizing employers' expectations of the communication abilities of new engineering graduates', *Journal on Excellence in College Teaching*, vol. 26, no. 4, pp. 125-47.

Sadler, D.R. 1989, 'Formative assessment and the design of instructional systems', *Instructional Science*, vol. 18, pp. 119-44.

Salamon, A., Sumsion, J., Press, F. & Harrison, L. 2014, 'Implicit theories and naïve beliefs: using the theory of practice architectures to deconstruct the practices of early childhood educators', *Journal of Early Childhood Research*, vol. 14, no.4, pp. 431–443.

Samuelowicz, K. & Bain, J.D. 2001, 'Revisiting academics' beliefs about teaching and learning', *Higher Education*, vol. 41, pp. 299-325.

Samuelowicz, K. & Bain, J.D. 2002, 'Identifying academics' orientations to assessment practice', *Higher Education*, vol. 43, pp. 173-201.

Savage, D. 2015, 'Illawarra engineers respond to #ILookLikeAnEngineer campaign', *Illawarra Mercury*, 6 August, viewed 13 January 2017, <https://www.illawarramercury.com.au/story/3263323/theyre-not-just-dudes-in-hard-hats/>.

Schatzki, T. 2002, *The site of the social*, Pennsylvania State University Press, University Park, PA.

Schatzki, T. 2005, 'The sites of organizations', *Organization Studies*, vol. 26, no. 3, pp. 465-84.

Schatzki, T. 2012, 'A primer on practices', in J. Higgs, R. Barnett, S. Billett, M. Hutchings & F. Trede (eds), *Practice-based education*, Sense Publishers, Rotterdam, pp. 13-26.

Schon, D. 1983, *The reflective practitioner*, Basic Books, New York.

Seymour, E. & Hewitt, N. 1997, *Talking about leaving: why undergraduates leave the sciences*, Westview Press, Boulder, CO.

Shannon, C.E. & Weaver, W. 1949, *The mathematical theory of communication*, University of Illinois Press, Urbana, IL.

Shapiro, A. 1991, 'WAC and engineering, or why engineers can't write', paper presented to the *42nd Annual Conference on College Composition and Communication*, Boston, MA, 21-23 March.

Sheppard, S., Macatanga, K., Colby, A. & Sullivan, W.M. 2009, *Educating engineers: designing for the future of the field*, Jossey-Bass, San Francisco, CA.

Shove, E., Pantzar, M. & Watson, M. 2012, *The dynamics of social practice: everyday life and how it changes*, Sage Publications, London.

Silverman, G. 2009, *Knowledge blindness and expert blindness*, viewed 18 January 2018, <http://mnav.com/expert-blindness>.

Skinner, I. & Mort, P. 2009, 'Communication skills developed within the engineering curriculum', paper presented to the *2009 Australasian Association of Engineering Education Conference*, Adelaide, 6-9 December.

Skinner, I., Mort, P., Calvo, R., Drury, H. & Molina, M.G. 2012, 'Some do, some don't: student use of online writing resources', paper presented to the *2012 Australasian Association of Engineering Education Conference*, Melbourne, 3-5 December.

Sørvik, G.O. & Mork, S.M. 2015, 'Scientific literacy as social practice: implications for reading and writing in science classrooms,' *Nordic Studies in Science Education*, vol. 11, no. 3, pp. 268-81.

Starke-Meyerring, D. & Paré, A. 2011, 'The roles of writing in knowledge societies: questions, exigencies, and implications for the study and teaching of writing', in D. Starke-Meyerring, A. Paré, N. Artemeva, M. Horne & L. Yousoubova (eds), *Writing in knowledge societies: perspectives on writing*, WAC Clearinghouse and Parlor Press, Fort Collins, CO.

Starke-Meyerring, D., Paré, A., Sun, K.Y. & El-Bezre, N. 2014, 'Probing normalized institutional discourses about writing: the case of the doctoral thesis', *Journal of Academic Language & Learning*, vol. 8, no. 2, pp. A13-27.

Starman, A.B. 2013, 'The case study as a type of qualitative research,' *Journal of Contemporary Educational Studies*, vol. 1, pp. 28-43.

Staszak, J.F. 2009, ‘Other/otherness’, in N. Thrift & R. Kitchin (eds), *International encyclopaedia of human geography*, Elsevier, Oxford, pp. 43-7.

Stevens, R., O’Connor, K., Garrison, L., Jocuns, A. & Amos, D.M. 2008, ‘Becoming an engineer: toward a three dimensional view of engineering learning’, *Journal of Engineering Education*, vol. 97, no. 3, pp. 355-68.

Stevenson, M. & Kokkinn, B. 2007, ‘Pinned to the margins? The contextual shaping of academic language and learning practice’, Journal of Academic Language & Learning, vol.1, no. 1, A44-A54.

Tonso, K. 2006, ‘Student engineers and engineer identity: campus engineer identities as figured world’, *Cultural Studies of Science Education*, vol. 1, pp. 273-307.

Trevelyan, J. 2007, ‘Technical coordination in engineering practice’, *Journal of Engineering Education*, vol. 96, no. 3, pp. 191-204.

Trevelyan, J. 2009, ‘Engineering education requires a better model of engineering practice’, paper presented to the *Research in Engineering Education Symposium 2009*, Palm Cove, Qld, 20-23 July.

Trevelyan, J. 2010, ‘Mind the gaps: engineering education and practice’, paper presented to the *2010 AAEE Conference*, Sydney, 5-8 December.

Trevelyan, J. 2012, ‘Why do attempts at engineering education reform consistently fall short?’, paper presented to the *2012 AAEE Conference*, Melbourne, Victoria, 3-5 December.

Turner, J. 1999, ‘Academic literacy and the discourse of transparency’, in C. Jones, J. Turner, & B. Street (eds), *Students writing in the university: cultural and epistemological issues*, John Benjamins, Amsterdam, pp. 148-60.

Turner, J. 2011, *Language in the academy: cultural reflexivity and intercultural dynamics*, Multilingual Matters, Bristol.

University of Sydney 2012, *WRiSE: Write reports in science and engineering*, viewed 11 March 2016, <http://learningcentre.usyd.edu.au/wrise>.

University of Sydney 2014, *iWrite*, viewed 24 June 2015, <http://iwrite.sydney.edu.au/iwrite.html>.

University of Technology Sydney 2017, *Student Guide to Capstone Project*, viewed 5 April 2018, <https://www.uts.edu.au/sites/default/files/Student_guide_to_capstone_project.pdf>.

Wajcman, J. 1992, 'Reviewed work(s): 'Pleasure, power and technology: some tales of gender, engineering, and the cooperative workplace' by Sally Hacker; 'Doing it the hard way: investigations of gender and technology' by Sally Hacker, Dorothy E. Smith and Susan M. Turner', *Signs*, vol. 17, no. 2, pp. 478-80.

Wajcman, J. 2010, 'Feminist theories of technology', *Cambridge Journal of Economics*, vol. 34, pp. 143-52.

Walker, M. 2001, 'Engineering identities', *British Journal of Sociology of Education*, vol. 22, no. 1, pp. 75-89.

Watt, R. 2011, *Concordance*, viewed 17 August 2015, <http://www.concordancesoftware.co.uk/>.

Wheeler, E. & McDonald, R.L. 2000, 'Writing in engineering courses', *Journal of Engineering Education*, vol. 89, no. 4, pp. 481-6.

Willey, K. & Gardner, A. 2012, 'Threshold exams to promote learning and assurance of learning', paper presented to the *2012 Australasian Association of Engineering Education Conference*, Melbourne, , 3-5 December, <www.aaee.com.au/conferences/2012>.

Williams, J. 2012, 'Use and exchange value in mathematics education: contemporary CHAT meets Bourdieu's sociology', *Educational Studies in Mathematics*, vol. 80, pp. 57-72.

Williamson, F. & Goldsmith, R. 2013, 'PASSwrite: recalibrating student academic literacies development', *Journal of University Teaching and Learning Practice*, vol. 10, no. 2, pp. 1-13.

Winberg, C. 2012, ''We're engaged': mechanical engineering and the community', in P. Trowler, V. Bamber & M. Saunders (eds), *Reconceptualising tribes and territories in higher education: practices in the 21st century*, Routledge, London, pp. 142-55.

Winberg, C., Winberg, S., Jacobs, C., Garraway, J. & Engel-Hills, P. 2016, ''I take engineering with me': epistemological transitions across an engineering curriculum', *Teaching in Higher Education*, vol. 21, no. 4, pp. 398-414.

Wingate, U. 2006, ' Doing away with 'study skills'', *Teaching in Higher Education*, vol. 11, no. 4, pp. 457-69.

Wingate, U. 2007, 'A framework for transition: supporting 'learning to learn' in higher education', *Higher Education Quarterly,* vol. 61, no. 3, pp. 391-405.

Wingate, U. 2014, 'Approaches in acculturating novice writers into academic literacy', in A. Lyda & K. Warchał (eds), *Occupying niches: interculturality, cross-culturality and aculturality in academic research*, Springer, Heidelberg, pp. 103-18.

Winsor, D.A. 1990, 'Engineering writing/writing engineering', *College Composition and Communication*, vol. 41, no. 1, pp. 58-70.

Winsor, D.A. 1992, 'What counts as writing? An argument from engineers' practice', *Journal of Advanced Composition*, vol. 12, no. 2, pp. 337-47.

Winsor, D.A. 1994, 'Invention and writing in technical work: representing the object', *Written Communication*, vol. 11, no. 2, pp. 227-250.

Winsor, D.A. 1996, *Writing like an engineer: a rhetorical education*, Lawrence Erlbaum Associates, Mahwah, NJ.

Winsor, D.A. 2006, 'Using writing to structure agency: an examination of engineers' practice', *Technical Communication Quarterly*, vol. 15, no. 4, pp. 411-30.

Wolff, K. & Hoffman, F. 2014, 'Knowledge and knowers' in engineering assessment', *Critical Studies in Teaching & Learning*, vol. 21, no. 1, pp. 74-95.

Wolff, K. & Luckett, K. 2013, 'Integrating multidiscipinary engineering knowledge', *Teaching in Higher Education,* vol. 18, no. 1, pp. 78-92.

Wulf, W.A. & Fisher, G.M.C. 2002, 'A makeover for engineering education', *Issues in Science & Technology*, vol. 18no. 3, pp. 35-39.

Yagelski, R. 2012, 'Writing as praxis', *English Education*, vol. 44, no. 2, pp. 188-204.

Yalvac, B., Smith, H.D., Troy, J.B. & Hirsch, P.L. 2007, 'Promoting advanced writing skills in an upper-level engineering class', *Journal of Engineering Education*, vol. 96, no. 2, pp. 117-28.

Yin, R.K. 2009, *Case study research: design and methods*, 4th edn, Sage, Los Angeles, CA.

Zevallos, Z. 2011, *‘What is otherness?’*, viewed 16 August 2017, <https://othersociologist.com/otherness-resources>.

Zhu, W. 2004, ‘Faculty views on the importance of writing, the nature of academic writing, and teaching and responding to writing in the disciplines’, *Journal of Second Language Writing*, vol. 13, pp. 29-48.