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 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.

Keywords: writing in engineering; practice architectures, practice theory, engineering curriculum

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 (US) and the Engineering Council (UK), 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, 2016 p.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

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underdeveloped (see for example: Goldsmith & Willey 2014; Goldsmith & 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, to write for particular audiences. This is known as the 'deficit model', which assumes that some students enter the academy with under-developed writing abilities, although there is little hard evidence to support this assumption. Despite decades of research and some excellent initiatives, both in Australian universities and elsewhere: (see, for example, Carter, Ferzli, & Wiebe, 2007; Fischer 2015; Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999; Lord, 2009; Mort &Drury, 2012; Pflueger, Weissbach, & Gallagher, 2015; Wheeler & 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 & 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 & 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 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. Fischer 2015; Pflueger, Weissbach & Gallagher 2015).

Table 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): typically 20 000-40 000 words

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 & Boud 2012).

By invisible we mean that writing practices are fragmented, ad hoc and not seen as developmental. 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 &

Boud 2012) but it is not uncommon that a report of several thousand words is given a weighting of 5-10% (Goldsmith & 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, p.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 & 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 lacking 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, p.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, 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.

Kemmis and colleagues (Kemmis & Grootenboer 2008; Kemmis 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 & Kirk, 2016) or team and project work in engineering practices (Buch & Andersen, 2015). Practice architectures theory 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, p.6).

A site of practice is 'that realm or set of phenomena of which it is a part' (Schatzki in Mahon, Kemmis, Francisco & Lloyd, 2017, p.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, 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. 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 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).

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. The interviews have been transcribed and analysed to identify emergent themes using Concordance software (Watt, 2011) 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.

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 development of writing practices in the engineering curriculum. We outline the practice landscape, the "arrangements necessary for the conduct of a practice" (Hemmings, Kemmis & Reupert, 2013, p.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 3 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 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%.

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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 p.3, 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, p.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 are 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 & Wenger 1991, p.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 & Kwan 2000; Samuelowicz & Bain, 2001). 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 practice architectures theory 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.

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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, p.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 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 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, to which Damien has made significant contributions. The report writing guide, 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, p.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, p.3). This outcome is supported by resources such as

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the report writing guide (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, p.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 Engineers Australia in its descriptors of the professional competency of communication (Engineers Australia, 2013, p.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 & 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 practice architectures theory 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 program, 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 programs 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 fulfill 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 for example Goldsmith, Willey & 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, p.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 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 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. Furthermore, 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 programs. 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, p.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, p.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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