

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 unsustainable 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 Engeström (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 relating 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 relating) 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.

The sayings, doings and relating of a practice are held in place by practice architectures

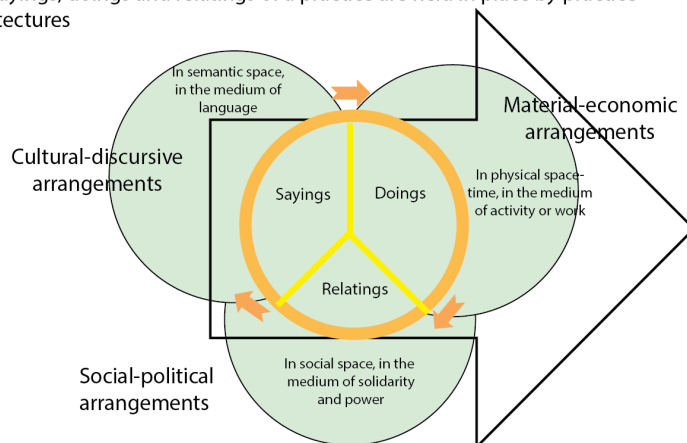


Fig.1: Practice architectures (Adapted from Kemmis 2013, p.3)

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.

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