Activity theory analysis of the visibility of writing practices in the engineering curriculum

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***Abstract**: Writing practices are seen to be essential for professional engineers, yet many engineering students and academics struggle with communicating in writing. This is despite the best efforts over many years of engineering educators and writing experts to develop writing strategies within or adjunct to the engineering curriculum. 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 the students and to the academics. The study uses activity theory to focus on interactions between individuals, writing practices and the engineering curriculum, to investigate what inhibits writing in the engineering curriculum at the level of engineering academics. The study identifies a number of tensions and contradictions in the development and practice of writing within the engineering curriculum.*

KEYWORDS

Writing practices in engineering; activity theory; engineering curriculum

Introduction

Writing is integral to engineering practice and is acknowledged as such both by the accrediting bodies such as Engineers Australia, ABET (US) and the Engineering Council (UK), and by the engineering faculties that teach engineering. Given the acknowledged importance of writing, 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 of communication is consistently reported as being underdeveloped (see for example: King, 2008; RAE, 2007; Sheppard et al., 2009). It is difficult to ascertain the reasons for the lack of visibility of writing 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; Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999; Mort & Drury, 2012; Wheeler & McDonald, 2000), little sustainable change has occurred, either in terms of the quality of student writing, or in employer perceptions of engineering graduates' written communication. This apparent lack of traction suggests that there are a number of factors that either inhibit the development of writing practices in the engineering curriculum, or render these practices invisible, and thus that the deficit may not lie so much with the

students as with the context surrounding the engineering curriculum. It also indicates a tension: 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 is adequately equipped to do so.

This tension in turn highlights the lack of research into the perspectives of writing held by engineering academics. 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 perspectives that engineering academics have towards their own writing practices and those of their students who are doing coursework rather than research degrees. 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 invisibility of writing practices in the engineering curriculum can quickly be established: a cursory examination of engineering subject outlines reveals that the majority of assessment tasks are focused on producing artefacts based on calculations rather than reasoned justifications. This is also reflected in the weighting of assessment tasks, where it is not uncommon that a report of several thousand words is given a weighting of 5-10%, while the final two- or three-hour examination has a weighting of 60-70% (Goldsmith, Willey & Boud 2012). It is easy to imagine how students with a strategic approach to learning will respond to this weighting, and will decide where to place the greater part of their efforts.

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. For example, when students are required to write a report, they may not be aware of the diverse sub-genres that fall into the genre of reports. This includes: 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 field-specific differences, such as the differences between a field report for mining engineering and a field report for chemical engineering. In addition, assessment criteria can be ambiguous and feedback from lecturers can be less than constructive; feedforward occurs very rarely. One outcome of this absence of guidance is engineering graduates who may lack the integrated knowledge required for engineering practice, and who may have limited communication capabilities.

This raises a number of questions: why is writing still so invisible in the engineering curriculum, despite widespread recognition of its criticality in engineering practice? Why is it difficult to ensure that writing practices are an integral element of what student engineers learn? In this paper we report on findings from a study that investigates what inhibits engineering academics from seeing the development of writing as part of their role as teachers of engineering. It also seeks to discover how writing can be framed so that it becomes a legitimate part of the curriculum owned by engineering academics.

Theoretical framework

Due to the complex nature of this topic, a number of theoretical lenses are being used in this investigation. The complexity lies in the invisibility of writing practices in the curriculum, in what kinds of knowledge are valorised in the engineering curriculum, in the ways that writing is viewed in the academy, in the role of pedagogy and epistemology, and in attempting to glimpse the dynamics of the teaching and learning of an engineering subject. This paper will

discuss the findings viewed through the lens of activity theory, which is both a theoretical perspective and a methodological tool. Engestrom's representation of activity theory (2001) is frequently used in educational contexts as it provides a way of looking at dynamic activities performed by the many actors involved in teaching, learning, assessment and the enactment of the curriculum.

Engestrom makes the point that standard theories of learning presuppose the following: when a subject acquires new knowledge or skills, the knowledge or skills "is itself stable and reasonably well defined. There is a competent 'teacher' who knows what is to be learned". However, much of what is learned at work is neither stable nor defined, nor is there a competent 'teacher'; thus there is a need for a different kind of learning theory that can provide an understanding of the learning that happens at work (2001, pp.137-139). It is possible to draw parallels with a typical engineering curriculum, where the learning is not always stable or defined, as pointed out by Walther and Radcliffe when they discuss the 'accidental competencies' of engineering education (2006).

Activity theory focuses on human actions not in isolation, but in the context of the larger human activity in which it is situated (Dias, Freedman, Medway & Pare, 1999, p.23). It thus enables an analysis of human actions in context (1999, p.27). It also reveals internal contradictions in practices, which can be overlooked when people focus on individual process and textual products (1999, p.28). **Activity theory 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. Thus AT analysis allows us 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. Fig 1 shows an example of two interacting activity systems, where the same activity viewed from perspectives of different subjects has different objects and potentially conflicting outcomes.

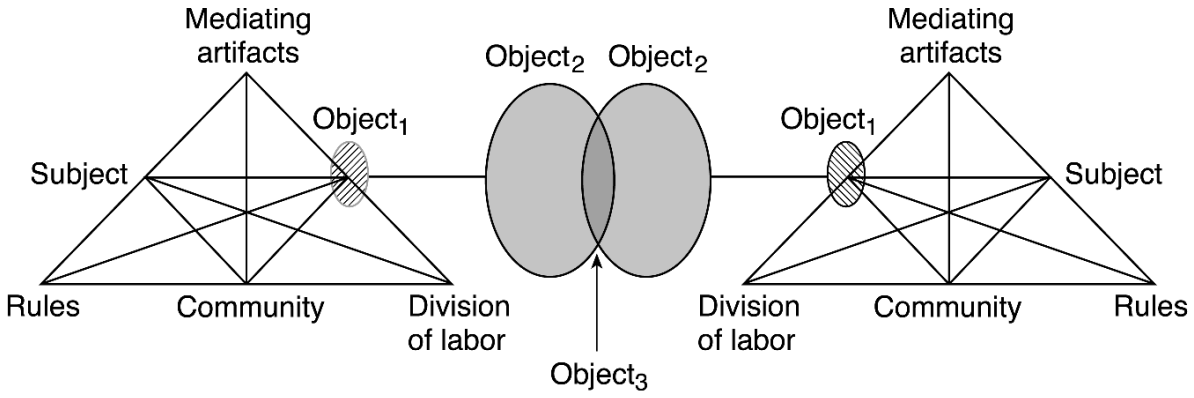

Fig 1: interacting activity systems showing differences in perspectives of the same activity (Engestrom 2001, p.136)

As previously noted, 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. Tensions are indicated within an activity system as breaks in the line of the triangle. An example of such a

tension might be in an activity system of an engineering faculty where a new technology in teaching is adopted; this leads to a contradiction in how faculty staff approach their teaching (a collision between the old and new elements of the division of labour). It will cause conflicts, but can also result in innovative changes to the activity of teaching.

Methodology

This study focuses on investigating what engineering academics and their students do, say, and write about writing practices in the engineering curriculum. This involves recruiting suitable participants. 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 targeted as they have a certain amount of control over what and how students are taught, and what and how students are assessed; potential participants at a number of Australian universities were contacted by email and invited to participate. The participants were asked to provide relevant documents such as subject outlines, support documents and samples of student assignments if available. I also searched for published writing by the participants (available in the public domain). 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 have been transcribed and analysed to identify key themes using Concordance (Watt, 2011). I then constructed activity systems from the collected data, using the engineering subject as the unit of analysis.The activity systems show the interactions among the elements of the system, including contradictions and tensions between the perspectives of the subject coordinators and their actions.

The second phase of the investigation involves recruiting students who have completed one of the subjects coordinated by one of the engineering academic participants; the students are invited to participate in focus group discussions about their views of writing practices in the engineering curriculum. Most of the questions are the same as those asked of the subject coordinators, with slight variations to accommodate their different roles. This phase is ongoing at the time of writing, so not all the data have been analysed; the activity systems of the students are currently being constructed.

Findings and Discussion

For this paper I compare two activity systems: one for participant 1 and one for participant 4. All participants have been de-identified, and are referred to by numbers. Their institutions are referred to by letters. Both participants teach technical subjects; they are from different universities (university A and university B) but both have been teaching for many years. In addition, both participants have several years' experience working in industry. These two systems have been selected as they illustrate some common tensions, but they also provide contrasts. To construct each activity system I used the analysis of documents provided by the participants (subject outlines, assessment task descriptors), the interview transcripts and the Concordance analysis of the transcripts.

The activity system for Participant 1 (fig.2) shows the elements of the system; the lines indicate the interactions between the elements. Tensions are marked as breaks in the lines. The diagram shows the following tensions:

- Tension 1: between the mediating tools (writing) and the rules, and between the subjects (Subject coordinator, students) and the object (report), between writing as learning and writing to produce an assessable artefact

One of the learning outcomes as stated in the subject outline is "**Report writing**: Students learn to structure their reports according to expectations in engineering practice" (Participant 1 subject outline 2014 p.3). In reply to the question "what do you see to be the purposes of

writing in your subject?" Participant 1 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"** (Participant 1 Assignment 3, 2014, p.1). A later interview comment by Participant 1 also contradicts the subject outline and the earlier 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* (Participant 1).

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.

- Tension 2: between the subjects and the object (report); between the subject, object and the outcome (demonstrated learning of the body of knowledge, learning how to write an engineering report, achieving a passing grade in the subject)

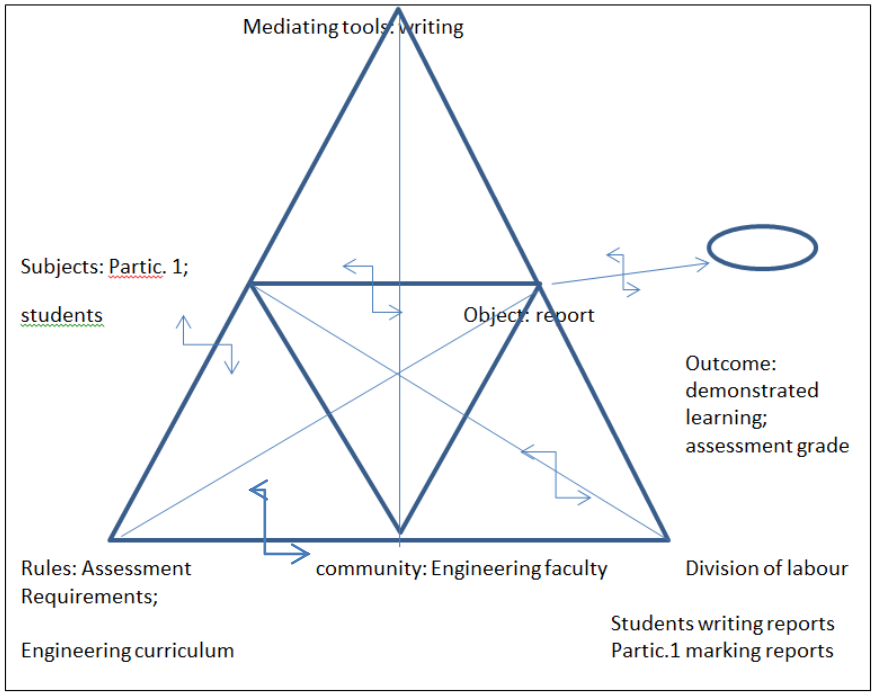

Fig.2: Activity system for Participant 1

It can be seen from the data provided for Tension 1 that a similar tension occurs in the goal-directed activity towards the object: there are few opportunities for students to learn how to write a report, yet they are expected to write three reports and to be assessed on them. When asked: "what opportunities are there for students to practise their writing in your subjects?" Participant 1 replies:

> *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* (Participant 1).

Participant 1 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 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. There is also a contradiction around the meaning of 'to practise'; on the one hand Participant 1 sees the assignments as an opportunity for students to practise their writing, but on the other hand the assignments are summatively assessed, so the opportunity to 'practise' without risking failure is not provided. This contradiction emerges in several other participants' activity systems, particularly between the stated importance of students being given opportunities for 'hands-on' practice with technical knowledge (e.g. in laboratory sessions), and the absence of opportunity for students to practise their writing without it being summatively assessed.

- Tension 3: between the perspective of the subject coordinator and the perceived perspective of the engineering faculty in regard to writing practices in the curriculum; the extent to which the subject coordinator sees themselves belonging to the community of the engineering faculty

This tension relates to the extent to which the subject coordinator sees writing practices being developed throughout the engineering curriculum and where his/her subject fits into this development; and the extent to which the subject coordinator sees the engineering faculty as a community to which they belong. The evidence for this tension can be found in responses to interview questions; how the subject coordinator refers to themselves (I/We); the description of the subject in the subject outline - whether it is described as being part of a sequence of subjects and whether preceding or subsequent subjects are acknowledged. When asked if they could see writing being developed sequentially, Participant 1 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" (Participant 1). The following question asked whether the participant's view reflected the faculty view: the response was "…I would say 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" (Participant 1). 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" (Participant 1 subject outline 2014, p.2).

The activity system for Participant 4 (fig.3) contrasts with that of the system for Participant 1 in a number of ways, most noticeably in the lack of tension between the subjects (subject coordinator, students) the mediating tools (writing, report writing guide) and the assessment requirements. The subject that Participant 4 coordinates feeds into the common curriculum of Mining Engineering Australia (MEA), which is a group of four universities that deliver a common curriculum for years 3 and 4 of the Bachelor degree in Mining Engineering. Participant 4 has co-authored a report writing guide for mining engineering students used by all the member universities of MEA. The report writing guide is a substantial document, providing extensive information about the field-specific requirements of mining engineering reports in terms of content, format, language and presentation. In this subject, students are required to complete two field trip reports in addition to other assessment tasks. The first report is preliminary, to provide students with formative feedback. The second report is based on the first one. Students therefore 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" (Participant 4) and through an online report writing site which features a mining engineering field report (Learning Centre University of Sydney WRiSE, 2012). There are also tensions in this activity system.

- Tension 1: between the subject (subject coordinator) and the community (engineering school, engineering faculty)

Participant 4 appears to identify strongly with the school in which they are situated, but not with the faculty. This is evidenced by interview responses where Participant 4 will not

comment on the faculty view, making the comment several times that “I can't talk about the faculty at all. I can only talk at the school level” (Participant 4).

- Tension 2: between Object (report) and Outcome (demonstrated learning, writing skills as a competitive edge); between *exchange value:* currency; what the students can ‘get’ for having high quality writing, and *use value*: intrinsic or useful in itself - how writing practices can deepen their understanding of what they are learning

Participant 4 provides strong support for students to learn to write engineering reports in the context of the field of knowledge (mining engineering), but 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” (Participant 4). For this participant, writing is a way of enhancing students’ competitiveness in the workplace, not necessarily that it will help them to think and learn better.

Both activity systems show tensions or contradictions between what the participants see to be the intention, purpose and enactment of writing practices in the curriculum; between writing to learn and writing to succeed in the workplace, and between writing as practice and writing to be assessed. There is also a disconnect between the subject coordinators and the engineering faculty in which they work: Participant 1 appears to be isolated from the faculty as a whole, while Participant 2 has a strong connection with the school but not with the faculty.

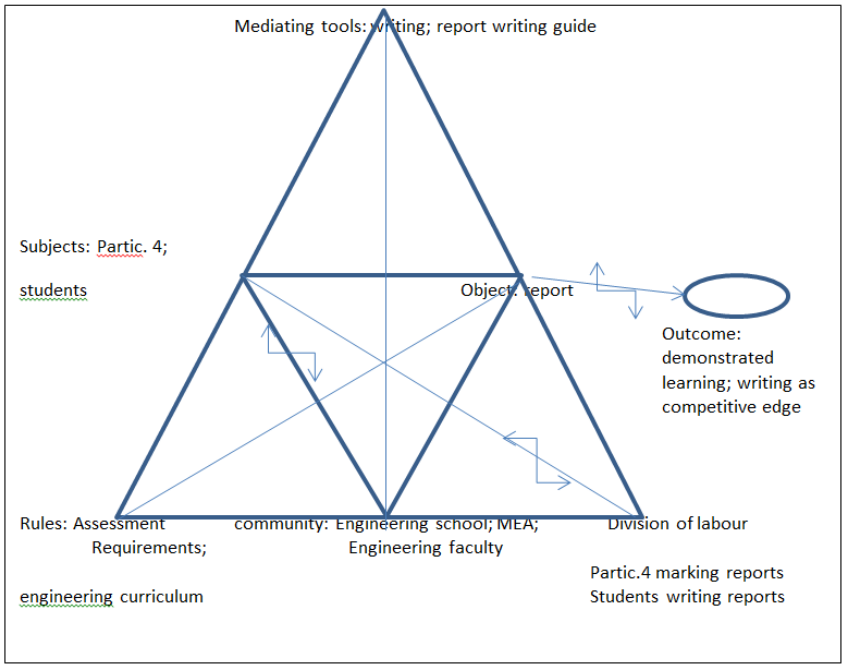

Fig.3: Activity system for Participant 4

These tensions 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 E 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

From the comparison of the two activity systems presented in this paper it can be seen that there are a number of tensions and contradictions in the development and practice of writing in the engineering curriculum. The tensions in Participant 1's activity system are to an extent typical of the majority of the participants, especially in regard to the lack of provision of exemplars of written tasks. However, the activity system of Participant 4 provides a strong model of how writing practices can be developed and supported in a field-specific context and throughout a degree program. What still needs to be resolved is the silo mentality that exists in a number of engineering faculties, where good practice may exist in one school but may be unknown and therefore invisible in another school. There are a number of aspects of the research that have not been included in this paper, but clearly it would be beneficial for engineering students to have the chance to learn from and through their writing, rather than being required to produce an assessable piece of writing that receives feedback after the fact, or not at all.

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