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Processes and tasks in collaborative writing in engineering: research-informed views and pedagogical applications

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Abstract

Writing plays a central role in the activities that engineers carry out both in academia and industry. Different from other disciplines, in engineering a considerable amount of writing takes place as collaboration between a group of individuals. Despite this recognition, research in collaborative writing (CW) in engineering is rather scant and the available studies are mostly theoretical in nature, with very little empirical evidence.

This article reports on an empirical study that examined CW in four schools at a faculty of engineering at a university in the UK. It specifically looks at the processes and the tasks in which engineering students and professionals get involved when writing collaboratively. Based on the findings of the study, the article suggests a number of research-informed pedagogical practices for developing CW in engineering.

Keywords: collaborative writing in engineering; processes and tasks in collaborative writing; pedagogical applications.

Introduction

Writing in engineering has been recognised to be a central activity in academia as well as industry (e.g. Kreth, 2000; Nelson, 2000; Reave, 2004; Day, 2011). It plays a substantive role in the life of both students and professionals, occupying a significant amount of their time (e.g. Bracewell and Witte, 2003; Gygi and Zachry, 2010). Coupled with this, research has demonstrated that engineering students and professionals seldom write alone, carrying out many writing tasks collaboratively (Nelson, 2000; Wheeler and McDonald, 2000; Calvo et al., 2011; Gimenez and Thondhlana, 2012). However, the number of

studies that have investigated collaborative writing (CW) in engineering is still rather limited, with a marked paucity in studies that look at how CW actually happens both in academia and industry.

This article reports on a study that examined writing processes and products in four schools at a faculty of engineering at a university in the UK (Gimenez et al., 2009). The empirical base of the study comprises a number of data sets that include observations, text analysis, 'talk around text' (Lillis, 2008), and interviews with a group of students and lecturers from the faculty. The article specifically focuses on the processes and the tasks that a group of students in one of the four schools got involved in to write collaboratively.

The article first presents a critical examination of the existing literature in CW in engineering, with a specific focus on the processes and the tasks usually reported in the literature. Against this background, it examines the findings of the study in an attempt to provide further empirical evidence to help advance our knowledge in this area. It concludes by suggesting a number of pedagogical applications for teaching CW in engineering.

Collaborative writing in engineering: processes and tasks

Writing has been identified to be central to most professional and academic activities in engineering, a vehicle for the construction and dissemination of knowledge, and a practice that reflects the ideology and values of the profession (Kreth, 2000; Nelson, 2000; Wheeler and McDonald, 2000; Winsor, 2001; Reave, 2004). It has also been recognised to be crucial for the education of future engineers (Kreth, 2000; Winsor, 2001; Day, 2011; Gimenez and Thondhlana, 2012).

By the same token, it has been pointed out that both engineering students and professionals seldom write anything alone. As one of the participating lecturers forcefully put it during his interview:

> Brunel did it all himself maybe but nowadays nothing is done like that and so because you're working, all your work is as a group then inevitably the writing is

> going to be in a group. [Int/03/Lec/3Es] (See appendix for an explanation of the abbreviations used to code the data)

As collaborative research articles, team project reports, design reports, and joint annual reports are becoming increasingly frequent in academia and the workplace, CW is gradually becoming more important (Calvo et al., 2011; Henderson and De Silva, 2006). Despite the recognition of its role and importance, empirical studies that examine CW in engineering are under-represented in the writing-in-engineering literature, especially in the UK. Coupled with this, existing studies on CW (e.g. Kreth, 2000; Nelson, 2000) have been based on interviews to students and professionals, with little or no observational validation of the processes writers tend to follow when writing collaboratively and the tasks they produce as teams.

In terms of the models that represent typical writing processes in CW, Henderson and De Silva (2006) and Lowry et al. (2004) have identified: the sequential, the parallel and the group single-author models. In the sequential model each member of a team writes following an agreed sequence. Once a member of the team has finished writing their part of the document, they pass it on to the next member in the sequence. In contrast, the parallel model requires team members to work in a simultaneous fashion. This model has been further divided into the horizontal-division and the stratified-division models. Whereas the first focuses on the ‘division of labour’, the second emphasises the ‘division of roles’. In horizontal-division model individual participants write different sections of the document that had been previously distributed at random. In the stratified-division model each member plays a particular role (e.g. team co-ordinator, writer, editor, or advisor), largely depending on their skills or talents. The group single-author model is usually used for simple writing tasks, about which consensus as to the final results can be easily achieved. In this model, one team member writes on behalf of their team.

Useful as these model descriptions have been, they are, however, largely theoretical, with very little empirical evidence to determine whether teams actually follow any of them or have other ways of writing collaboratively. In studies of CW in engineering, models are mostly theoretical in nature, with no or very little empirical evidence (e.g. Kreth, 2000; Nelson, 2002).

Together with these model descriptions there has been in the existing literature some explanation of other associated processes in CW. These mainly involve social and enabling processes that accompany the core writing processes. Among the social processes most commonly mentioned are discussing the composition of the team, team introduction and trust-building strategies. Other processes, which may seem peripheral to CW, yet equally important for teams to achieve their goals, include what can be termed 'enabling processes' (Menary, 2007). Enabling processes, which support and make possible writing activities, comprise asking for advice from external experts, seeking external approval (from a client, for instance), and evaluating IT tools for collaborative work.

The description of these processes has been accompanied by a reference to the tasks commonly carried out collaboratively, albeit sometimes in a cursory manner (Henderson and De Silva, 2006; Nelson, 2000). Collaborative research articles, module submission documents and course performance reports have been reported to be the most common tasks in which engineering lecturers get involved, whereas team project and joint annual reports rank high in the list of collaborative tasks in industry. Day and his team (2011) have identified a wider range of writing tasks which included emails, letters and reports to clients, although their study did not aim to identify what tasks were individually or collectively written. There is then a growing need for further research that offers evidence of how engineering students and professionals go about writing collaboratively so that we can develop a better understanding of the processes and tasks involved in CW.

The study reported on here had three main aims, to:

- Collect empirical evidence in support of the models used by engineering students and professionals when writing collaboratively.
- Examine the processes involved in CW.
- Create a taxonomy of collaborative tasks both in academia and industry.

This article mainly focuses on the first two aims.

The study: participants, data and methods

The study examined collaborative writing at four schools (Chemical Engineering, Civil Engineering, Electrical and Electronic Engineering, and Mechanical, Materials and Manufacturing Engineering) at the faculty of engineering of a university in the UK. Twenty-one final-year students and four academics, two of whom had substantial industrial experience, participated in the study. Although small, the sample of participants is representative of the composition of a faculty of engineering of this type. Students and lecturers represented the four major branches in the faculty, 16 students and 3 lecturers had English as their mother tongue and 5 students and 1 lecturer spoke English as a second or foreign language. There were 17 male and 4 female students and all lecturers were male. A breakdown of the participants is presented in Table 1.

Table 1. Distribution of participants by School.

School	**Students**	**Lecturers**	
		University	University + Industry
Chemical Engineering	6	1	
Civil Engineering	4		1
Electrical and Electronic Engineering	4	1	
Mechanical, Materials and Manufacturing Engineering	7		1
Total	**21**	**2**	**2**

The empirical base of the study comprises observation notes, text analysis, ‘talk around text’ (Lillis, 2008), and interviews. The study started with an exploratory group meeting which aimed at identifying the processes that a group of final-year students usually went through to write collaboratively. Based on the views and descriptions offered at this meeting, questions were designed for the semi-structured interviews. These questions covered three central areas: the nature and role of CW in engineering, the processes (writing, social and enabling) and models followed, and the tasks written collaboratively. The data from the interviews were later complemented with data from group tutorials where lecturers and students discussed how the students had gone about writing

collaboratively and the writing tasks they were producing or, at a later stage, had produced.

Of the written tasks the groups had written collaboratively, the study focused on design reports in considerable detail. Design reports were selected as they represent a central and recurrent writing practice in engineering, both in academia and industry. As Gibson (1998) has stated, design is essential in engineering as it involves creativity, synthesis and problem-solving, the three central processes underlying many practices in engineering. After the groups had submitted their final reports, consent was sought and seven reports were randomly chosen from a set which had already been marked as successful by the lecturers in the schools. Preliminary analysis of the chosen texts was followed by 'talk-around-text' sessions where student writers discussed their perspectives about the texts they had written. An overview of the data collected is offered in Table 2.

Table 2. Overview of data sets.

Method of data collection	Participants	Data
Exploratory group meeting	Students	Narratives: Audio recordings
First round of Interviews	Lecturers	Views & perceptions: Audio recordings
Second round of Interviews	Students	Views & perceptions: Audio recordings
Group tutorials	Students and lecturers	Tutorial discussions: Audio recordings and observation notes
Document collection	Lecturers and Students	Documents: Project briefs and guidelines, design reports
Talk around text	Students	Writers' perspectives about their texts: Audio recordings

Findings and discussion

This section provides a discussion of those findings which are the most relevant to the issues addressed in this article. It has been divided into two subsections. Subsection one deals with the processes and the models reported by the students during the exploratory meeting and the interviews, and by the lectures during interviews. Data collected at the

group tutorials and the ‘talk about text’ sessions are also used. The second subsection presents an exploration of the tasks that the students wrote collaboratively. Data for this section come from the documents collected and the interviews.

Processes in CW

This subsection first refers to the writing processes that the participating students got involved in when writing collaboratively. It then examines the social and enabling processes that accompanied CW.

Apart from writing itself, the most recurrent writing processes the groups we studied got involved in were planning and editing. Planning consisted of number of cycles which included: deciding how to write the report, which involved breaking it down into manageable sections, agreeing on the objectives of each section (e.g. extended summary, supporting evidence) and distributing them to individual members of the team, and who was going to assume editorial responsibilities for the final report.

Planning was defined by the students as an important activity in writing collaboratively. They clearly identified it as the first activity they got involved in when they met for the first time:

> Before we set out to do anything we had a group meeting where we looked at the general project, we decided what we needed to do, how to go about doing it, and who was doing what. [EMtg/01/St/3Ms]

They also described planning as cyclical and needing to be revised as their project progressed:

> As we worked on the project and developed different sections we realised [we] needed to get together again and again to discuss new planning strategies, we learnt that planning all at once was not going to work actually… [Int/07/St/3Es]

> When we constructed the extended summary we had a group meeting where we sat down together and looked at the general, for the general and extended summary, we sat around a table and said, ‘Can you see any problems with how this

> goes with that? Can you see any problems with this, that?' All the way through the general section, so we have an understanding of how the process works and how things interact by kind of being able to say, 'Could we have done this part better? Could we have done that part better? How does this fit?'. [Tut/03/3Ms]

These processes were also mentioned by the lecturers in their interviews:

> You certainly need to have formed and agreed an overview of the document so that people know what they've got to do but they know what everybody else is doing as well and how the whole thing will come together. I mean that's not a particularly sophisticated strategy but I think it's sometime missed. Yeah I think it's very important for everybody to have the overview. [Int/02/Lec/CvE]

> …we are saying to the student groups you really need to have a general view of the project and have your lines of communication within the group very clear. You need to know how you're bringing things together, which bits have been done by which individuals. [Int/01/Lec/ChE]

As these quotes illustrate, planning is quite central to CW. More important though is the fact that planning recurs as the documents the groups write develop, requiring them to meet several times to adjust their initial plans. During these planning meetings, members also decide who is doing what. This is usually distributed by interest and skills:

> When we worked on stretching the extended summary it was very beneficial that [name of team member] and [name of team member] collated the whole document, everyone's section into one document, they are very good at doing that…it would have made writing the extended summary hugely difficult if we just had everyone's section without being able to all of us go away, read through everything and then come to that meeting… [Tut/02/3Es]

> We each had areas where we were stronger than other group members. I took this part here [the economic part] because I've done a course in economics/finance so I can appreciate. [TAT/03/CvE]

This division of labour is also common in industry although it happens by expertise rather than interest:

> …it entirely depends on your specialism. It might be a report on the rationale for a public development, perhaps you have two or three lead inspectors, an engineer who will probably have a different approach, and then marketing departments who also like to do their own thing, but ideally a team would capitalise on the expertise of each of its members… [Int/06/Lec/3Ms]

> So if you're tendering to build a road you have to demonstrate that you know how to build a road but you also need to demonstrate that you understand the environmental and social impacts of that. You need to demonstrate that you've looked at whole life issues, you know, how, the way it's built will impact on future maintenance requirements and things like that. You need to demonstrate that you've considered how to minimise and then deal with ways that you generate and these are all specialisms that no one individual can cover. [Int/02/Lec/CvE]

As seen in the findings presented here, CW requires planning to be flexible and on-going. As the task progresses, teams need to make adjustments to the plans they originally made when they first met so that planning remains relevant to the task. By the same token, cyclical planning will allow team members to have an overview of the task and its latest developments. This is also important for making decisions about how the requirements of the task are going to be divided among the members of the team. Underlying all this is the need for establishing an effective communication strategy and keeping communication channels clear, as will be discussed later on in the article.

Editing, the other recurring writing process, was also recognised as important in CW both in academia and industry as one of the lecturers mentioned during the interview:

> Virtually all the work you do will be very actively reviewed by at least a colleague, which is an essential collaborative exercise even if it isn't every other word…it is impossible to write on your own. If you don't have a critical review, the quality of any work is lower, so collaboration's then vital in professional life. [Int/02/Lec/CvE]

As a process, editing included decisions about who was going to assume editing responsibilities which, in some groups, started very early in the planning process:

> We also started thinking about the editor you know who was good with detail, who was best at nit-picking [laughter]. [EMtg/01/St/3Ms]

It was also interesting to discover that for most groups how editing was going to take place depended on the section being edited. For the extended summary, for example, the editor would compile the different drafts and critique, revise and edit each before the group met together to discuss the new edited version of the summary. In the case of the supporting evidence section, however, each writer in charge of a section would be both the writer and the editor, with no group editing of each individual section taking place:

> Student: For the group work [extended summary] everyone sent me and [name of team member] the group work and we put it all together as one big document because it needed to follow straight through.
> Tutor: First folder?
> Student: Yeah, and then for the second bit [supporting evidence] everyone put their own bit because it's easier to have everything separate like that. Everyone writing and editing their own section […] [TUT/03/3Ms]

For other sections, the alternative design section for instance, yet another process was followed. The editor would put the different parts together and edit the resulting document, but the other members of the team would also participate in the editing process:

> It depends on the section. Let's say alternative design here. It was broken down and we went away and did our own research to start with and came back with different designs. We then decided to cut out any redundancy, any repeats, any plant design so that it was possible to arrive at that because it was theoretical, etc…we had this process each person chose to process a little section of the work on their section. The sections were then submitted, in this case, [name of team member] who collated them into a word document. Edited, inserted punctuation, changed words around. This document was then opened up to everyone to read through, criticise, modify and edit until we were happy. [TAT/04/3Ms]

It is interesting to notice that, like planning, editing in CW is also cyclical and closely related to the task or section of the task the team was involved in. It appears that the section of a document would determine how editing is distributed. As shown above, editing could be the responsibility of a single person, that is, the editor of a section written by different members of the team, the writer of a given section, or a responsibility shared by the whole team, as in the case of the alternative design section.

Of the enabling processes that accompanied writing, the most salient was the choices and possibilities offered by technological applications. The most frequently mentioned by the different groups was the chance of sharing documents on-line, thus making the writing and editing processes more efficient:

> This is actually what happened with this one. With the advents of online file sharing anyway which we've got with Office Live Work Space so it was really helpful because it means that you could automatically just send everyone the updated piece of work. So basically it's a good thing because that means the others are updated everyone could just see it right there in an instant. You don't even have to print out anything. We've got a new feature with Microsoft which we use quite a lot which tracks the edits from other people's, from the other guys' comments because it actually does comment and highlight the sections which have been edited by the other person. It makes the interaction much more efficient. [TAT/01/ChE]

> Yes. [name of team member]'s work was submitted to this online portal thing and you could just open the document up and review it. We just turned on track changes in word where you insert comments and made changes and it showed up in the document. [TAT/02/3Es]

One of the most interesting findings of the study is the type of processes and the models followed by the participating teams of writers. Despite the neat descriptions presented in the existing literature, our findings indicate that CW is more cyclical in nature than we had first believed, and that groups tend to mix different models or parts of models depending on the nature of the task at hand (see Table 3).

Table 3. CW models and mix of models.

CW Model	Definition	Variation
Sequential	Group members write a specific section of the task in sequence.	Sequential stratified-division (sections distributed according to skill, talent or seniority)
Parallel	Group members write a specific section of the task in parallel.	Parallel horizontal-division (sections distributed at random)
		Parallel stratified-division (sections distributed according to skill, talent or seniority)
Group single author	One writer writes on behalf of the group.	
Mixed	Parallel stratified-division + Group single author	

Summarising, CW requires groups to get involved in a series of cycles of writing and editing, possibly more frequently than they had anticipated when they met for the first time. This has clear implications for the communication strategies that teams need to put in place: how to communicate with one another, at what points in the writing processes and through which media. Technology certainly plays a decisive role in the communication of the teams, as will be later discussed.

Similarly, from analysing the results there emerges a clear link between processes and writing tasks. In particular, the study has shown that the decisions teams make about planning, writing models and editing are closely related to the nature of the task they are doing. The groups we interviewed and observed used different models for different tasks. For example, they used stratified division writing of the parallel model for the extended summary of their design project which required a group decision about the final written product and demanded higher levels of collaborative editing. In the case of tasks that did not require this level of convergence (e.g. writing the supporting evidence section of the project) students and professionals alike usually chose a mix of models. Of the possible combinations available to writers, the ‘stratified division of the parallel model and the group single- author’ combination appeared the most frequent. In a similar vein, when writing technical papers, for instance, academics and professionals in industry prefer a combination of a primary author who was responsible for writing most of the document and a primary editor who was in charge of editing the final draft. This could be named the

sequential stratified-division model. Table 3 summarises the models identified in the existing literature, together with the combination of models made by the participants of the study (shaded areas).

Main tasks in CW

As mentioned above, students and professional engineers write a wide variety of documents (Day, 2011) both in academia and industry. Different report types (e.g. lab, progress and design reports) rank the highest, but participants also mentioned research papers (in academia), tendering documents, instructions and specifications (in industry), and proposals (in both settings):

> I do engineering consultancy in industry which involves writing reports with other people. But then of course we also write research papers with colleagues. [Int/06/Lec/3Ms]

> For consultants that's what they do generate reports. For contractors, that's the set of people that actually go and build things. Even then there's a lot of group writing involved because there'll be a tendering process and then there'll be a process which very often these days for large and often public sector construction jobs consultants and contractors who in the past might have worked separately, so a consultant will work at the design stage and the contractor at the construction and maintenance stage more and more often now are being asked to work together at the design stage to reduce the risk that someone designs something which the contractor then says can't be built that way. [Int/02/Lec/CvE]

> Yes, it obviously depends what you're specialising in but most of us have written reports of some type whether it is lab reports, progress or design reports. We have also written proposals for the design project. I have friends who have also had to write sets of instructions, you know, to tell people how to follow a process for example. They had to write specifications to technicians to operate a certain type of machine or a software manual for computers. [Int/05/St/ChE]

As noted by Day and his colleagues (2011), reports for clients were singled out by the lecturers as being of high importance, especially after students graduate and move into industry. The key and challenging issue in this type of reports is writing for an audience who has no or very little technical knowledge, something that the existing literature seems to overlook:

> Because the more senior you are in the organisation the more likely you are to understand the client for which you're writing the report. You know that they probably don't have sophisticated technical knowledge so you have to write in an accessible manner cause you may want to send your draft to the client and say, 'what do you think of this draft?' and the client reads it and throws up implications they might have considered before and they want to come back to you and say, 'hmm I think you need to add a bit about this or that'…this is something students are very rarely told about. [Int/02/Lec/CvE]

The tasks mentioned in the interviews constitute an emerging taxonomy of tasks in CW, as presented in Table 4.

Table 4. Emerging taxonomy of tasks in CW.

Academia	**Industry**
Project design reports Academic articles (e.g. research papers) Module specifications Course revision reports Laboratory reports Proposals	Project design reports Tendering documents Progress reports Laboratory reports Instructions Specifications Proposals

From the results discussed in this section, there emerge a number of processes that should be taken into consideration when teaching and researching CW in engineering:

- Planning is a whole-team activity that would be better approached as a flexible, on-going process that is closely linked to the different stages involved in writing a task.
- Planning meetings provide all members with an overview of the task and its development, and an opportunity to contribute to the task with their own individual skills, talents or expertise.

- Editing is also cyclical but, depending on the section of the writing task, it can be a whole-team or individual activity so team members would need to identify which section or sections are to be edited individually and which collaboratively.
- Communication is central for successful task completion as are communication tools such as applications for on-line composing and editing, therefore team members would need to establish their communication strategies, including on-line tools, as early as possible.
- Models for CW seem to be chosen by groups depending on the type of writing tasks at hand. Groups also choose to combine different models to facilitate writing; it is then important for groups to consider which combinations are more useful to the task they are doing.
- Writing tasks are central to the activities engineers get involved in and seem to increasingly occupy a considerable amount of their time, it would therefore seem advisable for writers to explore those that are more effectively written as collaboration.

Research-informed pedagogy for collaborative writing in engineering

There are three fundamental aspects of CW that pedagogical practices for developing writing in engineering would need to consider. They are the:

- Nature of planning in writing collaboratively.
- Role of communication skills.
- Appropriate technological tools to support CW.

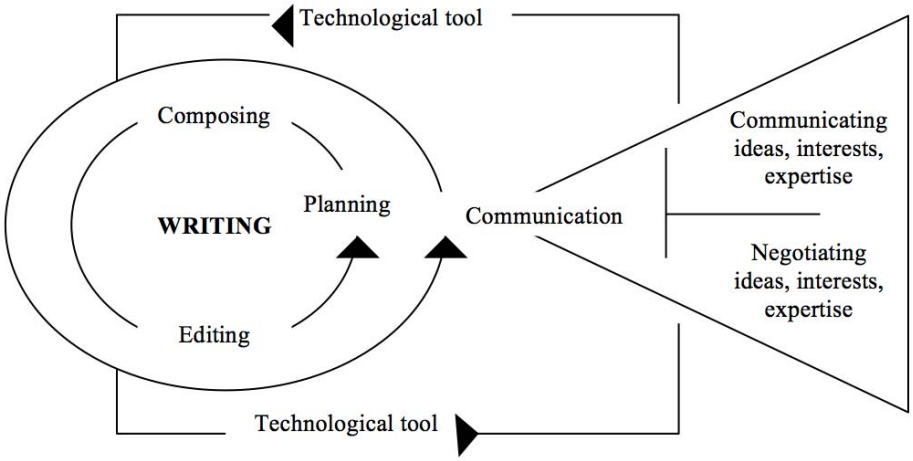
As shown in the previous section, planning is a central process in CW that consists of a number of cycles, involving planning, composing and editing. Thus, it would be beneficial for student writers to become aware that keeping planning flexible will facilitate decisions to be easily adjusted and modified as new needs arise with the development of the project. This flexibility will also facilitate the composing and editing processes involved in CW. To this end, students may be provided with opportunities for discussing skills for effective planning, breaking down tasks into more manageable mini-tasks, and evaluating strategies for mid-term and long-term planning.

The second central aspect of CW that emerges from the findings of the study reported on here relates to communication skills. These can be seen as a set of enabling skills which comprise strategies for writers to be able to communicate their ideas, interests (especially in academia) and expertise (especially in industry) about the different sections of the task being developed. Based on this, students benefit from opportunities to develop skills that enable them to negotiate their individual positions and ideas about both the content (e.g. when discussing the supporting evidence for a design project they are in charge of) and the structure of the writing task (e.g. when planning, composing and editing a report).

The final aspect that could be used to inform pedagogical practices for CW teaching concerns technological tools that support the communication activities of teams. As reported by the students in the project, online applications are very effective for sharing documents at different stages of the writing process. In this sense, student writers could be made aware of different applications for collaborative work (e.g. Google documents, Office Live Work Space, Wickis, writeboard). They could be encouraged to experiment with different applications so that they become proficient users as most require a certain level of expertise and may be rather demanding for the novice writer (Calvo et al., 2011), learn to choose the most efficient for their own purposes, and identify those that lend themselves more easily to the part of the task they are involved in writing.

Figure 1 shows how these aspects of CW are linked together when writing collaborative tasks:

Figure 1. Fundamental aspects of CW in engineering.



Conclusion

This article has shown ways in which research has contributed to our understanding of CW as a professional practice in engineering. It has provided some empirical evidence for the processes, models and tasks that engineering students and professionals engage in when writing collaboratively. Following the findings of the study, the article has also discussed a number of aspects that pedagogical practices for developing writing in engineering should consider. These principles should, however, be further explored and evaluated in a follow-up, classroom-based study.

Further research in CW in engineering is needed. We still need to understand, for example, how teams writing collaboratively make decisions about leadership, the dialectical relationship between writing, social and enabling processes and tasks, and the facilitating roles that technologies play in CW. It is hoped that these areas of further enquiry will open up new avenues for research in this emerging area of discipline-specific writing.

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Appendix

Abbreviations used to code the data.

EMtg	Exploratory meeting
Int	Interview
Tut	Tutorial
Doc	Document
TAT	Talk around text
0+number (e.g. 03)	Order of collection of data
Lec	Lecturer
St	Student
3Es	Electrical and Electronic Engineering
ChE	Chemical Engineering
CvE	Civil Engineering
3Ms	Mechanical, Materials and Manufacturing Engineering