Using a Corpus-Based Approach to Explore Writing Variation in Engineering Subdisciplines: Pedagogical Implications

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Abstract
In the contemporary academic culture where publications are highly valued, engineering graduate research students are generally expected to publish their research outcomes during their doctoral candidature. Writing for publication can be challenging if one is not aware of the writing conventions in a subdiscipline. Furthermore, technical textbooks have been found to give contrasting and fragmentary advice regarding the use of passive voice to novice writers who intend to write in engineering subdisciplines. In response, some scholars have suggested engaging students with authentic language data relevant to the field, thus helping them better understand language conventions in their discipline. This study used *AntConc*, a corpus analysis tool, to explore writing variation on the use of the first-person pronoun with an active verb and the use of passive voice, as well as their rhetorical functions in journal abstracts, across eight engineering subdisciplines. A main corpus of 480 most-cited paper abstracts from 8 engineering subdisciplines was compiled and divided into 8 sub-corpora. Each sub-corpus consists of 60 abstracts from the top 5 journals in the field. *AntConc* was used to explore and analyse all the sub-corpora. The findings reveal significant variations across these engineering sub-disciplines in terms of usage frequency and rhetorical functions. To train engineering graduate research students in research writing, awareness in sub-disciplinary writing variation should be enhanced, and language analysis tools can be introduced for the students to further train themselves to be well-informed writers in their respective sub-disciplines.

Keywords: Graduate Research, Subdisciplinary Writing Variations, Engineering Subdisciplines, Corpus Analysis

Introduction

In addition to faculty members, graduate research students are the main driving force of research at a university. Graduate research students work on innovative ideas under the guidance of their supervisors and further develop these ideas into research outcomes or industrial solutions. In the contemporary academic culture where publications are highly valued, graduate research students are generally expected to write for publication to communicate the outcomes of their research during their doctoral candidature. However, writing for publication can be challenging if the writer is not aware of the disciplinary writing conventions. One of the questions on writing convention that engineering graduate research students frequently ask is the use of active or passive voice in research writing. However, writing advice provided by technical communication text books to this question can be inconsistent and fragmentary (Conrad, 2018).

One way to deal with this issue is to provide students with more discipline-specific writing assistance (Boettger & Wulff, 2016). With this approach, understanding disciplinary writing variation has become increasingly important and relevant in instructional design and pedagogy (Boettger & Wulff, 2016; Cargill & Adams, n.d.). Moreover, engaging students with authentic language data is deemed a more practical means to help students understand the linguistic patterns used in their respective disciplines. In this regard, corpus-linguistic approaches have been seen as valuable tools to understand variation in technical and scientific writing for pedagogical purposes (Boettger & Wulff, 2016; Cargill & Adams, n.d.).

Many studies have been conducted to investigate various aspects of language use in a number of disciplines, such as reporting words in medical journals (Thomas & Hawes, 1994), personal pronouns in scientific journals (Kuo, 1999), the passive voice and reporting verbs in engineering (Boettger & Wulff, 2016), the use of the first-person pronouns in electrical engineering (Wang et al., 2021) and personal pronouns across soft and hard disciplines (Harwood, 2005; Hyland, 2003; Khedri, 2016). Most of the literature in this area has focused either on the analysis of linguistic features in one single discipline or on cross-disciplinary linguistic variations. Few studies have focused on variation of linguistic patterns across sub-disciplines within the engineering discipline.

This study aims to investigate language use in the abstract of eight engineering sub-disciplines, focusing on the use of active and passive voice, which has been an object of debate in engineering research writing for decades, and the use of first-person pronouns, particularly ‘we’, which has gained increasing attention in engineering research writing. The investigation aims to answer the following research questions:

- What is the extent and distribution of the use of passive voice in the abstract of engineering research articles across subdisciplines?
- What is the extent and distribution of the use of pronoun ‘we’ in the abstract of engineering research articles across subdisciplines?
- Does the extent and distribution of the passive voice vary across sub-disciplines in engineering?
- Does the extent and distribution of the pronoun ‘we’ vary across sub-disciplines in engineering?
- Is there any correlation between the use of passive verbs and that of the pronoun ‘we’ in general?
- What are the rhetorical functions of the ‘we’ pronoun in the abstract?

Such a study can further inform our understanding of sub-disciplinary variation. Its findings may be useful to graduate research students who would like to understand style and linguistic patterns in their respective fields for publication purposes.

Active Voice, Passive Voice and the First-Person Pronouns

The passive voice has been one of the most researched and debated clarity markers in scientific writing (Leong, 2020). For example, research writing style in the 17th century was characterised by the use of active voice; however, the style gradually shifted to being object-oriented after the industrial revolution (Ding, 2002; Leong, 2020). According to Ding (2002), "the passive voice in scientific discourse embodies the professional practices and rhetorical contexts of science…Scientists through employing passive voice in their writing tell scientific communities that what they present can be replicated and verified by the communities" (p.152). Passive construction has been deemed to have a place in engineering writing (Stewart, 1984), and its use has been thought to encourage precision and probity (Leather, 1996).

However, in recent years, there seems to be a paradigm shift which favours the use of active voice to improve clarity and conciseness (Foster, 2017). It has been found that many technical guides encourage users to avoid using the passive voice as it is deemed to be top-heavy, cumbersome and confusing (Banks, 2017; Wolfe, 2009). The use of passive voice is criticised for generating ambiguous sentences (Day, 2011). In addition, world leading publishers such as Nature and IEEE also encourage prospective writers to avoid using the passive voice. They advocate using the first-person pronoun 'we' as the subject in active construction. The influence of these journals could be far-reaching and have great impact on the various science and engineering communities. In fact, some diachronic studies on scientific writing has shown increasing use of the active voice at the expense of passive forms (Banks, 2017; Leong, 2020), and the use of active voice has been found to be related to the use of the first-person pronoun subjects.

> *The study found that the extent of passive use was stable from 1880 to 1980 (occurring in about 29–36% of all clauses) but declined in 2017 (averaging below 25%). The study also found a decline in the use of finite passives to describe methodological actions and a corresponding increase in the use of first-person pronouns in the 2017 articles.* (Leong, 2020, p.467)

In addition to addressing clarity issue, the use of first-person pronoun subjects together with active verbs is also associated with authorial stance (Hyland, 2003; Tarone et al., 1981). The use of 'we' as a subject in active construction is a rhetorical strategy (Harwood, 2005; Hyland, 2003; Tarone et al., 1981). Hyland (2003) has identified 4 rhetorical functions with self-mention through first person pronouns, some of which have also been identified by other researchers (Harwood, 2005; Tarone et al., 1998). The four rhetorical functions of self-mentions in research articles proposed by Hyland (2003) include: 1) stating a goal or outlining the structure of a paper, 2) explaining a procedure, 3) stating results or making a claim, and 4) elaborating an argument (p. 257). Harwood (2005) stresses that 'we' is used for self-promoting, with which the authors present unique or innovative methodological procedure, clarify their stance, and report or summarize findings. In a much earlier study, Tarone et al. (1981) also highlight that the first-person plural active is used by authors to contrast their work with those of other contemporary researchers. With reference to the above-mentioned, the rhetorical functions of the 'we' pronoun can be summarised as follows.

1. Stating the purpose or goal
2. Outlining the structure of a paper
3. Presenting one's stance or contrasting one's stance with others'
4. Elaborating an argument
5. Presenting unique research procedure or design
6. Presenting findings or contributions, or making a claim

However, not all publishers or authors of technical guides advocate active construction and the use of the first-person pronouns. The American Society of Civil Engineers, for example, stresses the importance of passive voice: "The passive voice is not intrinsically poor, despite what many writing textbooks and grammar-checkers tell us. We need the passive voice; it stops us from repeatedly having to use 'I' and 'we' or some other agent" (Silyn-Roberts Heather, 2004, p.198). Some researchers also argue that using the passive voice does not always lead to problems and its use is essential in some cases (Krisch & Houdek, 2015).

Because of the historical background and preferences of some journals, it is not hard to see why engineering researchers or technical communication scholars have very different or even contrasting views about the use of active and passive voice, and the use of first-person pronouns in research writing. In fact, some scholars have found advice and views on the use of passive voice in technical and scientific writing inconsistent and fragmentary (Boettger & Wulff, 2016; Conrad, 2018). This may have to do with the propositions of specific journals or sub-disciplines within engineering.

Unfortunately, this means that graduate research students can get conflicting information from engineering and technical communication text books (Wolfe, 2009) and blanket advocates of either the active or passive voice in research writing in different sub-disciplines. More empirical explorations about the use of active and passive voices especially in the engineering subdisciplines could inform the ongoing discussion. This paper contributes to the topic by investigating the use of passive construction, active construction with the 'we' pronoun, and the rhetorical functions of the 'we' pronoun in several sub-disciplines of engineering.

Description of the Self-Compiled Corpora and Analysis

Four hundred and eighty abstracts from the journals of 8 engineering sub-disciplines were collected and compiled to build a corpus. The corpus was divided into 8 sub-corpora, each with 60 most-cited or most popular abstracts from the top 5 journals in the field (Table 1).

The abstract is chosen for analysis in this study because it has been viewed as the most important part of a research article (Stojmenovic, 2010). In addition, Omidian et al. (2018) highlight that fundamental distinctions, in terms of linguistic features and rhetorical functions, among disciplines can be noticed through the analysis of abstracts.

Journal selection was based on the ranking of top journals in the respective sub-disciplines, according to *Google Scholar Metrics*. The papers were randomly selected from the most cited or popular categories in the last 1 to 3 years as listed by each journal.

Sub-corpus	Number of abstracts per sub-corpus	Number of words
1. Environmental and Geological Engineering	60	13956
2. Transportation	60	12529
3. Robotics	60	12038
4. Materials Engineering	60	11920
5. Fluid Mechanics	60	12695
6. Structural Engineering	60	12638
7. Electromagnetism	60	11036
8. Chemical Kinetics and Catalysis	60	11518

Table 1: Data description

Two linguistic features, i.e., the first-person pronoun 'we' and passive verbs, were investigated in all the sub-corpora. The 'we' pronoun was first searched in each sub-corpus and the number of hits was recorded. The number of sentences were also manually calculated to facilitate a comparison on the use of 'we' pronoun on per sentence basis.

To retrieve all instances of passives, any form of the verb BE (e.g., am, is, are, was, were, has been, have been, had been, will have been) was searched in *AntConc* (Anthony, 2005) and the resulting concordance was copied into a spreadsheet. The concordance lines were manually inspected to identify true hits of finite passive verbs, as shown below:

- Basic (be + past participle)
- Progressive (be + being + past participle)
- Perfective (have/has/had + been + past participle)
- Modal (modal + be + pp)
- Modal perfective (modal +have been+ past participle)

The number of passive verbs was calculated against the number of sentences.

Chi-square tests were conducted to investigate statistical significance of variation in terms of the use of the 'we' pronoun and passive voice across the 8 sub-disciplines, and Pearson correlation tests were conducted to see if there was any correlation between the use of the 'we' pronoun and passive verbs.

The most frequent verbs associated with the 'we' pronoun were also explored and analysed to discover their rhetorical functions.

Results and Discussion

Frequency of the 'We' Pronoun

Table 2 provides information on the use of the 'we' pronoun across all sub-disciplines.

Sub-discipline	Hits (occurrences)	Number of sentences	Number of 'we' at the sentence level (60 abstracts per sub-corpus)
Robotics	128	424	3.3
Fluid Mechanics	93	450	4.8
Transportation	77	485	6.3
Chemical Kinetics and Catalysis	40	306	7.7
Materials Engineering	29	419	14.4
Structural Engineering	31	475	15.3
Environmental and Geological Engineering	25	502	20.1
Electromagnetism	16	400	25

Table 2: The use of the first-person pronoun 'we'

Among all the abstracts, the 'we' pronoun appears the most frequently in Robotics (1 in every 3.3 sentences) and the least frequently in Electromagnetism (1 in every 25 sentences).

A chi-square test of independence was conducted to test the following hypotheses:

H0: Abstracts in different sub-corpora do not differ in the use of the 'we' pronoun.

H1: H0 is false.

The result – χ^2 (7, N=98330) = 205, $p < 0.00001$ – shows that there are statistically differences in the use of the 'we' pronoun in the abstracts of different fields.

To further verify the above results, the number of abstracts which contain the 'we' pronoun was also tabulated, as presented in Table 3.

Sub-discipline	Number of abstracts which contain at least one occurrence of 'we'	Number of abstracts which do not contain any 'we'	Number of abstracts in each sub-corpus
Robotics	49	11	60
Fluid Mechanics	35	25	60
Transportation	26	34	60
Chemical Kinetics and Catalysis	24	36	60
Materials Engineering	15	45	60
Environmental and Geological Engineering	13	47	60
Structural Engineering	9	51	60
Electromagnetism	8	52	60
Total	179	301	480

Table 3: The number of abstracts containing the 'we' pronoun

As shown in Table 3, the majority of the abstracts (301/480, 63%) do not contain any 'we' pronoun. The 'we' pronoun appears the most frequently in Robotics and the least frequently

in Electromagnetism. Forty-nine out of 60 abstracts (82%) contain the 'we' pronoun in Robotics but only 8 out of 60 (13%) in Electromagnetism do.

A chi-square test of independence – χ^2 (7, N=480) = 101, $p < 0.00001$ – confirmed that there are statistical differences in the use of the 'we' pronoun in the abstracts of different fields.

Frequency of the Use of Passive Verbs

The use of passive verbs was also explored across all sub-disciplines, and Table 4 details the results.

Sub-discipline	Hits (occurrences)	Number of sentences	Number of passive verbs at the sentence level (60 abstracts per sub-corpus)
Structural Engineering	350	475	1.4
Electromagnetism	226	400	1.8
Environmental and Geological Engineering	231	502	2.2
Chemical Kinetics and Catalysis	142	306	2.2
Materials Engineering	180	419	2.3
Robotics	150	424	2.8
Fluid Mechanics	157	450	2.9
Transportation	133	485	3.6

Table 4: The use of passive verbs across sub-disciplines

Passive verbs appear the most frequently in the abstracts of Structural Engineering (1 in every 1.4 sentences) while the least frequently in those of Transportation (1 in every 3.6 sentences).

A chi-square test of independence on a slightly modified form of the data shown in Table 4 (based on a coarse assumption of the number of sentences per hit) was conducted to test the following hypotheses:

H0: Abstracts in different fields do not differ in the use of passive voice
H1: H0 is false

The results – χ^2 (7, N=3461) = 232, $p < 0.00001$ – showed that there are statistically significant differences in the use of passive voice in the abstracts of different fields.

Correlation Between the Use of the 'We' Pronoun and Passive Verbs

A Pearson correlation test was conducted to explore if there was any correlation between the use of the 'we' pronoun and passive verbs. The results showed that there is a high negative correlation (-0.69) between the number of 'we' per sentence and the number of passive verbs per sentence. This shows that the sub-disciplines which use more 'we' also tend to use fewer passive verbs. This finding adds to the discussion that the use of 'we' may affect the use of passive voice in research writing (Banks, 2017; Leong, 2020).

Overall, the 'we' pronoun appears more frequently in the abstracts of subdisciplines such as Robotics, Fluid Mechanics and Transportation while less in those of Environmental and Geological Engineering, Structural Engineering, and Electromagnetism. It should be noted that most abstracts of the Robotics sub-corpus and of the Electromagnetism sub-corpus were extracted from IEEE journals (4 out of 5), respectively. In general, IEEE journals encourage the use of 'we' and active construction in research writing, and the findings for Electromagnetism seem at odd with this guideline.

Such variations could be due to the nature of the studies or sub-disciplinary conventions, which needs further investigation. For example, Bank (2017) mentions that authors tend to use the 'we' pronoun and active construction when expressing/demonstrating a mental process such as mathematical calculation. This study did not consider the research nature of the abstracts, which should be further investigated in future studies.

Linguistic Patterns in Writing the Research Aim

An analysis was also conducted to discover the linguistic patterns of the purpose/goal statements in the abstracts. Table 5 shows the results.

In terms of presenting the purpose/aim, 'This paper/article/study/work + active construction' is found to be the most frequently used across subdisciplines (35%), followed by the use of passive construction (31%) and 'We + active construction' (30.4%). This implies that the three patterns have their respective places in writing the research aim/purpose of engineering research articles. Compared with the other two, 'This paper/article/study/work + active construction', indicating a more neutral formulation (Foster, 2017), seems to be preferred by most engineering research writers across a few sub-disciplines in this study, particularly in Transportation and Environmental and Geological Engineering. The findings show that despite the encouragement to use active construction, passive construction is often used in writing the research aim, with about 1/3 of the abstracts across subdisciplines using passive construction to present the research aim/purpose. In Materials Engineering and Electromagnetism in particular, about half of the papers present the research aim/purpose in passive construction. As for 'We + active construction', it happens the most frequently in Robotics.

Subject of the sentence	Robotics	Structural Engineering	Chemical Kinetics and Catalysis	Fluid Mechanics	Electro-magnetism	Materials Engineering	Transportation	Environmental and Geological Engineering	Total occurrences (percentages)
We +active construction	42	10	21	27	7	13	19	7	146 (30.4%)
This paper/article/work/ study + active construction	15	25	11	13	22	16	35	31	168 (35.0%)
The aim/objective/purpose of this study		1		1			1	4	7 (1.5%)

Noun+ passive construction	3	23	26	15	31	30	4	17	149 (31.0%)
The authors+ active construction						1			1 (0.2%)
No clear purpose statement		1	2	4			1	1	9 (1.9%)
Number of abstracts	60	60	60	60	60	60	60	60	480 (100%)

Table 5: Linguistic patterns of the purpose/goal statements

'We' Collocation and Rhetorical Functions

An analysis was also conducted to explore what verbs collocated with the 'we' pronoun and what rhetorical functions they served. Frequently seen clusters (i.e., 3 occurrences and above) of the 'we' pronoun and corresponding verb, and their rhetorical functions are listed in Table 6.

We-verb collocation	**Frequency**	**Rhetorical functions**
1. We present	36	Purpose; contribution
2. We propose	35	Purpose; procedure; claim
3. We show	25	Purpose; contribution; claim; stance
4. We demonstrate	20	Purpose; procedure; claim
5. We review	14	Purpose; procedure
6. We discuss	13	Procedure; stance
7. We highlight	10	Purpose; stance; claim
8. We study	10	Purpose; procedure
9. We provide	10	Purpose; contribution; procedure
10. We use	10	Procedure
11. We report	9	Purpose; procedure; contribution
12. We identify	9	Procedure; stance; claim
13. We introduce	8	Purpose; procedure; contribution
14. We address	8	Procedure; claim
15. We find	7	Stance; procedure; contribution;
16. We perform	6	Procedure
17. We investigate	6	Purpose; Procedure
18. We examine	5	Purpose; Procedure
19. We hope	4	Stance; claim
20. We observe	4	Procedure
21. We conclude	4	Claim; stance
22. We derive	4	Procedure
23. We conduct	3	Purpose; procedure
24. We leverage	3	Procedure
25. We refer to	3	Procedure
26. We implement	3	Procedure

Table 6: We-verb collocation and rhetorical functions

The clusters in the table above show the various rhetorical functions of the 'we' pronoun collocating with different active verbs. Frequently seen rhetorical functions are presenting the

research procedure, stating the research purpose, presenting one's stance, and highlighting one's claim or contribution, which align with the findings of previous studies.

Conclusion

This paper seeks to explore whether there is any variation in terms of the use of the 'we' pronoun and passive construction in the abstracts across eight engineering subdisciplines, and it was found that the variation is statistically significant. Writers in certain subdisciplines, such as Robotics and Fluid Mechanics, tend to use the 'we' pronoun more often in their sentences as compared to writers in subdisciplines such as Electromagnetism and Environmental and Geological Engineering.

On the other hand, passive verbs appear more frequently in subdisciplines such as Structural Engineering and Electromagnetism, showing that the passive voice does have a place in engineering research writing. It may not be too practical to advise engineering researchers, especially graduate researchers, to avoid the passive voice in their writing as such blanket advice may not suit engineering research writers of different sub-disciplines.

Overall, there is also a negative correlation between the use of 'we' as the subject of active construction and the use of the passive voice, which means that if 'we + active construction' is more frequently used, there will be less passive construction in the abstracts.

In addition, the rhetorical functions of the 'we' pronoun with the corresponding verbs found in this study also align with those of previous studies whereby the use of the 'we' pronoun serves as a promoting strategy to state the research purpose, present authorial stance, describe the research procedure, make a claim or highlight contributions.

One pedagogical approach to equip engineering graduate researchers with knowledge about the writing conventions in their respective research fields is to introduce the concordance tool so that they can explore linguistic patterns in their specific discipline while writing for publication.

As the corpus size in this study is small, the findings should be seen with this caveat in mind. Nevertheless, they do provide a glimpse of language variations in engineering subdisciplines, perhaps showing that academic writing instructors should avoid giving blanket advice when it comes to writing for publication across sub-disciplines. For future studies, the relation between the nature of the study and the use of the 'we' pronoun should also be considered and further researched.

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