Genre practices in mechanical engineering academic articles: Prototypicality and intra-disciplinary variation

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Abstract

Since move analysis was proposed by Swales (1990), numerous studies have adopted this method to explore organisational patterns in different sections of research articles in a range of disciplines. However, research articles in mechanical engineering have attracted scant attention in genre analysis research. This paper will be among the first to identify move structures of the Results-Discussion section of research articles in this under-explored discipline. To this end, it draws on a corpus of 18 original research articles that employ different research types (experimental, theoretical and mixed). The findings show the prototypicality as well as variability in genre practices associated with different disciplinary contexts. The findings have important implications for the design of corpora used in genre analysis.

Keywords: move analysis, rhetorical structure, mechanical engineering research articles, inter-/intra-disciplinary variation.

Resumen

Prácticas genéricas en artículos académicos de ingeniería mecánica: prototipicidad y variación intradisciplinar

Desde que Swales (1990) propuso el análisis de movimientos retóricos, son numerosos los estudios que han adoptado este método para explorar los patrones de organización en diferentes secciones de los artículos de investigación de varias disciplinas. Sin embargo, los artículos de investigación en ingeniería mecánica apenas han despertado el interés de la bibliografía sobre el análisis de géneros. Este trabajo es uno de los primeros que identifica estructuras de

movimientos retóricos en la sección de resultados-discusión de artículos de investigación de esta disciplina, apenas explorada hasta ahora. Para ello, se ha analizado un corpus de 18 artículos originales que recurren a diferentes tipos de investigación (experimental, teórica y mixta). Los resultados muestran la prototipicidad y la variabilidad que se producen en prácticas asociadas con diferentes contextos disciplinares. Estos resultados tienen importantes implicaciones para el diseño de corpus empleados en el análisis de géneros.

Palabras clave: análisis de movimientos, estructura retórica, artículos de investigación en ingeniería mecánica, variación interdisciplinar e intradisciplinar.

1. Introduction

Research articles (hereafter RAs) are considered to be the primary mode of conveying new knowledge within an academic context (Yang & Allison, 2003; Pho, 2008; Lim, 2010 & 2011; Basturkmen, 2012). Understanding how RAs in a particular discipline are constructed structurally and linguistically is of great importance since it can enable students to communicate more effectively in their target discourse community (Berkenkotter & Huckin, 1995). In the field of English for Specific Purposes (ESP), genre analysis, conceptualised most notably by Swales (1990) in his influential work on the rhetorical structure of the RA Introduction, has become a useful tool in explicating important features of genres, including organisational patterns (realised by moves and steps), as well as linguistic features. A move is "a discoursal or rhetorical unit that performs a coherent communicative function in written or spoken discourse" (Swales, 2004: 228). While the concept of move captures the communicative purpose of a segment of text at a more general level, a step is the rhetorical means of realising the function of moves (Yang & Allison, 2003: 370).

Motivated by Swales's approach, a multitude of studies have explored various aspects of genre, including move structure and/or linguistic features, functional variation in different genres, and genre variation in different cultural contexts, or a combination of these research strands. As genres are characterised by communicative purposes and content that can be recognised by members of a discourse community (Swales, 1990), gaining genre knowledge involves first recognising structures and patterns of language use associated with a specific genre. There has been extensive research examining rhetorical structures of individual sections of RAs in a

single discipline, for example in applied linguistics: Abstract (dos Santos, 1996), Discussion (Basturkmen, 2009); software engineering: Introduction (Anthony, 1999); management: Introduction (Lim, 2012); forestry: Introduction (Joseph, Lim, & Nor, 2014); biomedical: Methods (Musa, Khamis, & Zanariah, 2015); dentistry: Discussion (Basturkmen, 2012); management: Methods (Lim, 2006); sociology: Results (Brett, 1994); medicine: IMRD sections (Nwogu, 1997); chemistry: A-IMRD sections (Stoller & Robinson, 2013).

While analysts agree that a specific genre shares some features in terms of rhetorical structures and linguistic mechanisms, they also acknowledge variability in a single genre that can be associated with different cultural contexts: research paradigms (quantitative, qualitative, mixed) (e.g. Lim, 2010), linguistic (Sheldon, 2009), institutional (Pho, 2008), or disciplinary cultures (Hyland, 1998 & 1999; Peacock, 2002; Ozturk, 2007; Vazquez & Giner, 2008; Peacock, 2010; Lim, 2011). For instance, Lim (2010) explored possible effects of research methods employed in RAs on genre practices by looking at the similarities and differences in the way researchers in applied linguistics and education comment on their findings in the Results sections of RAs adopting different methodologies: quantitative, qualitative and mixed. He calculated the number of occurrences of commentary instances based on the number of times one commentary type appears without being interrupted by another. The finding showed that there were no statistically significant differences in commentary practice between RAs using different research types.

It is clear that genre-based research agendas have multiple strengths. They have provided great insights into writing conventions in many different contexts. The past studies have also drawn attention to the effect that contextual factors may have on rhetorical choices, thus challenging the view that genre practices are monolithic. In addition, the findings from the genre-based research has greatly informed the teaching and learning of language for specific purposes. However, further research is needed for several reasons. First, little is known about writing practices characterising many other disciplines. Studies into RAs in individual disciplines have offered in-depth understandings of genre practices typical of the fields. Many more similar studies can be undertaken to provide the important information in other under-researched disciplines.

Further understandings of genre conventions in a specific discipline have also been achieved through comparisons and contrast with others, and a

myriad of studies have explored unity and variation in textual properties among many different disciplines. In many large genre projects (e.g. Cotos, Huffman, & Link, 2015; Cotos, Link, & Huffman, 2016; Cotos, Huffman, & Link, 2017), however, there seems to be a lack of explanations for the similarities and differences that may reflect characteristics associated with the disciplines being examined. The description resulting from the large-scale analysis thus tends to be reduced to a generalisation among RAs belonging to different disciplines. The findings may be of less pedagogical value for students who wish to comprehend underlying factors shaping the conventions adopted in their field of study and research. In brief, small-scale genre analysis research, coupled with views elicited from expert informants, is still important if insights into specific fields are to be gained.

The second reason is that results obtained from the past studies need to be verified in further research. Different studies employ many different approaches to identifying moves and steps, leading to different results and different interpretations of the results. These approaches differ mainly in the unit of analysis and the unit of realisation. In many studies (e.g. Cotos et al., 2016), the unit of analysis is the sentence, meaning that if multiple sentences constitute a move/step, a tag is assigned to each sentence. In others (Lim, 2010), the unit of analysis can be the sentence or many sentences, meaning that if multiple non-interrupted sentences express the same function, one tag is assigned to the sentences. In some studies (Yang & Allison, 2003), a move/step is realised by a sentence without consideration into units below the sentence level. In others (Kanoksilapatham, 2003), a move/step can be realised by any grammatical units as long as it contains a propositional meaning. The differences in the way rhetorical units are identified can imply two things. First, this poses a challenge to make comparisons and contrast between results obtained from different studies. Second, the results obtained can be partial, as they are limited to a particular analytical approach. These implications necessitate further investigation, even of the same phenomenon, using various approaches to yield more reliable information on textual properties for a particular discipline.

Third, genre analysis research often focuses on some textual aspects in a small number of articles, with an exception of, for instance, the study by Cotos and her colleagues, as move identification is such an arduous task that it is not possible to explore all features related to a particular discipline. Further research is therefore still needed to provide a fuller picture of the discipline. As a response to these research needs, our study continues the

current body of genre-based research in one under-explored discipline – mechanical engineering – by exploring structural features of RAs in the discipline and possible variation within the community. To the best of our knowledge, no research to date has explored intra-disciplinary variation in the structural features of mechanical engineering articles on the level of research methods that are adopted in the articles.

The current research focuses on the Results-Discussion section. The decision was made after we surveyed 30 randomly selected articles in mechanical engineering, and found that the majority of them have a combined Results and Discussion section, which accords with Lin and Evans's (2012) finding that a hybrid Results and Discussion section is common in mechanical engineering articles (158). Furthermore, this section is an important venue realising the main goal of an academic article because in this section, researchers present and discuss findings of their study, and make new knowledge claims to show how their study contributes to the field (Brett, 1994; Basturkmen, 2009).

Our study provides an analysis of the prototypicality and diversity in genre practices by examining two research questions:

1. What are the moves and steps used to realise the Results-Discussion section of articles in mechanical engineering?
2. Are there any differences in move structure among articles that use different research methods?

To address these questions, in the section that follows, we delineate procedures for constructing the corpus, and outline methods of move analysis. We then present results from rhetorical analyses and, where possible, discuss these findings with reference to the relevant literature. We close the paper with a review of the main findings, implications, and directions for future research.

2. Materials and methods

2.1. Corpus construction

First, we developed a sampling frame, consisting of categories and sub-categories representing the language being examined in the present study

(see Table 1). Sources from which texts were selected to represent the hierarchical system were high-quality journals (ranked Q1 according to Journal Citation Report) in mechanical engineering.

Article types	No. or articles	Publication years
Experimental (EX)	6	2011-2016
Theoretical (TH)	6	2011-2016
Mixed (MX)	6	2011-2016

Table 1. Sampling frame.

Several criteria were further applied during the selection of RAs. First, the articles should be written by different authors to avoid any idiosyncrasies. Second, the articles within the same article type should be sourced from different journals to ensure that the corpus is as representative as possible. Third, the articles should be published in recent years with the year of 2011 as the oldest to minimise possible variation in time. The fourth criterion is that the articles should have an integrated Results-Discussion section, followed by a stand-alone Conclusions section. The sections may have conventional headings (e.g. 'Results and discussion', 'Conclusions'), or varied functional headings (e.g. 'Simulation results and discussion', 'Summary').

The sampling frame served as a basis for the selection of articles included in the corpus. The second author, who has domain knowledge in mechanical engineering, identified high-ranking journals and selected articles based on the sampling frame and the pre-established criteria. It turned out to be difficult to find one article falling within the time frame, and therefore an article from 2008 was included in the corpus. Given the very small number, it can be assumed that there is almost no significant effect on the representativeness of the whole corpus. A list of the articles finalised for the corpus can be found in the appendix. The pdf files of the articles were downloaded and saved in names uniquely representing the categories/sub-categories they belong to.

2.2. Methods of analysis

2.2.1. Move analysis approach

We adopted an inductive approach to move analysis, meaning that we did not use any analytical frameworks proposed in the literature, in order to allow for the identification of communicative functions that are distinctive of

mechanical engineering articles. In fact, we did not find any move-step frameworks identified specifically for the group of articles in the present study. However, we consulted relevant existing analytical schemes (e.g. Kanoksilapatham, 2003; Yang & Allison, 2003; Cotos et al., 2015; Musa et al., 2015; Cotos et al., 2016), and recycled their move/step labels, yet with more detailed explanations of the functions performed by the moves/steps to avoid any confusion. In the present study, we identified moves/steps based on the content of the text, as well as linguistic cues, as it has been suggested that these two aspects are closely intertwined, and both play crucial roles in the interpretation of communicative functions. It should be noted however that content and context was given priority over linguistic signals, especially misleading ones, when pragmatic interpretations of particular text segments were made.

2.2.2. Move analysis procedures

Following previous studies (Cotos et al., 2016; Moreno & Swales, 2018), the identification of moves/steps in the present study involved two main phases: segmenting the section into meaningful functional-semantic discourse units and categorising the segments into a workable move-step scheme.

Phase 1: We read the whole article to gain a broad understanding of the content, although the focus is on the Results-Discussion section. We then read the section carefully and broke it into meaningful functional-semantic units. These discourse units can be realised by any grammatical unit such as a sentence, a clause, a phrase, a group, or even a word. However, the basic unit of analysis was the sentence, which was further detailed in Table 2. There are many instances in the present corpus where there are not clear clause boundaries due to inappropriate use of punctuation (see, as an example, the extract from TH6 in Table 2). In these situations, content and linguistic signals were used to decide the type of sentence and the segmentation rule to follow. After the texts were segmented into discourse units, these units were labelled, and their communicative functions were recorded.

Phase 2: Based on their communicative functions, the functional-semantic discourse units segmented in the first phase were categorised into a tentative move-step scheme.

The two phases of coding were repeated for each of the articles. The tentative coding scheme was constantly reviewed and revised during the

fragmentation and categorisation of each text. The product of the procedures was a coding scheme that contains a significant number of categories including many moves, steps and sub-steps. This coding scheme was then revised so that the number of categories was reduced. The sub-steps under the steps were not included in the final coding scheme but incorporated into the functional descriptions of the moves/steps. After identifying the move structure and patterns of variation, we attempted to explore underlying factors shaping prototypical and individual rhetorical choices in the mechanical engineering articles. To do this, we drew on our own speculations, domain knowledge of the second author, and insights from three mechanical engineering informants, who are researchers at one university in New Zealand.

2.2.3. Coding tools and coders

The segmentation and classification were conducted on the article pdfs using the software *Nvivo*. The two authors of this paper together coded the texts, which involved extensive discussions. We are well aware that the process of move/step identification involves a degree of subjectivity (Crookes, 1986; Holmes, 1997; Anthony, 1999). Joint coding and multiple discussions between the authors can enhance the reliability of coding.

Sentence type	Segmentation scheme	Examples from the corpus
Sentence with one independent clause		
One overall communicative function without more specific functions	One tag for the sentence	<Report results> *Specifically, when the location of O2 injection moves outward from the inner ring, the high-temperature zone somewhat moves downstream.* </Report results> [TH1]
One overall communicative function with more than one specific function	One tag for the sentence Additional tags for other elements of the sentence	<Locate information> <Report results> *Mass flux variation of the present numerical simulation results versus degree of sub-cooling …* </Report results> *are described in Fig. 8.* </Locate information> [MX1]
Sentence with more than one independent clause		
The clauses performing the same overall communicative function	One tag for the sentence Additional tags for other elements of the sentence (as needed	<Report results> *Moreover, it is obvious that conduction is the dominant mechanism at the air region in higher aspect ratio …, but the natural convection play major role at air region ….* </Report results> [MX3]
The clauses performing different overall communicative functions	Different tags for the clauses in the sentence Additional tags for other elements of the clauses (as needed)	<Account for results> *The increased heat transfer between two phases brings their temperature close to each other* </Account for results> <Report results> *thus the fluid phase and solid phase temperature field look similar at higher values of H,* <Explicate results> *which reveals that the solid and fluid phases are in a state of thermal equilibrium* </Explicate results>. </Report results> [TH6]

Table 2. Segmentation protocol.

3. Results and discussion

In this section, we present noticeable move/step phenomena emerging from the analyses of the Results-Discussion section, including the overall schematic structure, the move/step range and coverage, and cyclical patterns. First, we describe general trends, and compare, when possible, the textual features of the articles in mechanical engineering with those in other disciplines. It should be stressed that the comparison is not a direct one, given the differences between the present study and those in the past in terms of the section being examined (Results-Discussion vs. Results/Discussion/Discussion-Conclusions section) as well as the segmentation scheme (multi-layer coding vs. sentence as the unit of realisation). We then turn to exploring individual differences in the structural features of the mechanical engineering articles using different research types.

3.1. Prototypicality

In this sub-section, we describe the move-step framework identified from the corpus and their associated properties including the range (referring to the number of articles that contain a particular move/step), the coverage (how much of the Results-Discussion text a move/step is realised in) and the cyclicity (the repetition of moves/steps and the co-occurrence of moves/steps).

3.1.1. Move/step framework

Table 3 outlines the communicative functions of the Results-Discussion section. The move/step framework proposes the most common sequence of occurrence of moves/steps, but does not imply a simply fixed order. The actual occurrence follows a logical presentation of scientific arguments, as noted by Cotos et al. (2015: 55). Table 4 shows the range and the coverage of the moves, and Figure 1 provides the range on the step level of the most frequent moves (those occurring in at least half of the texts in the corpus).

Communicative functions
Move 1 Provide background information
Step 1 Restate aims and objectives
Step 2 Provide background knowledge
Step 3 Refer to previous studies
Step 4 Restate study procedures
Move 2 Provide information about the methodological approach
Step 1 Provide a context for the methodological approach
Step 2 Restate the method
Step 3 Describe the method
Step 4 Restate important notes about the method
Step 5 Validate the method
Move 3 Present results of the study
Step 1 Justify reasons for reporting specific results
Step 2 State notes about the presentation of results
Step 3 Report results
Step 4 Report supporting results
Step 5 Report conflicting results
Move 4 Validate the results
Step 1 State the source(s) for comparison
Step 2 Acquire data from other sources
Step 3 Report comparison results based on data obtained from different sources or situations
Step 4 Account for agreement or mismatch
Step 5 Explicate comparison results
Step 6 Comment on the reliability of the results and the method
Move 5 Comment on the results
Step 1 Explicate the results
Step 2 Account for the results
Step 3 Evaluate the results
Move 6 Summarise the results
Move 7 Evaluate the study
Step 1 Indicate limitations
Move 8 Make deductions
Step 1 Make suggestions
Step 2 Recommend future research
Other functions
Locate information
Make announcements
Indicate the structure of the section
Announce moves or steps
Provide clarifications
Define terms
Explain table or figure elements

Table 3. Framework of communicative functions in the Results-Discussion section.

Communicative functions	Range	Coverage	No. of occurrences	Average no. of occurrences
Move 1	89%	7%	117	6.5
Move 2	94%	11%	148	8.2
Move 3	100%	47%	595	33.1
Move 4	83%	11%	143	7.9
Move 5	100%	19%	254	14.1
Move 6	11%	0.4%	5	0.3
Move 7	11%	0.3%	4	0.2
Move 8	39%	2%	18	1.0
Locate information	100%	15%	276	15.3
Indicate the structure of the section	33%	0.5%	6	0.3
Announce moves or steps	50%	0.2%	13	0.7
Define terms	2%	0.5%	7	0.4
Explain table or figure elements	28%	0.8%	11	0.6

Table 4. The range, coverage and number of occurrences of the moves.

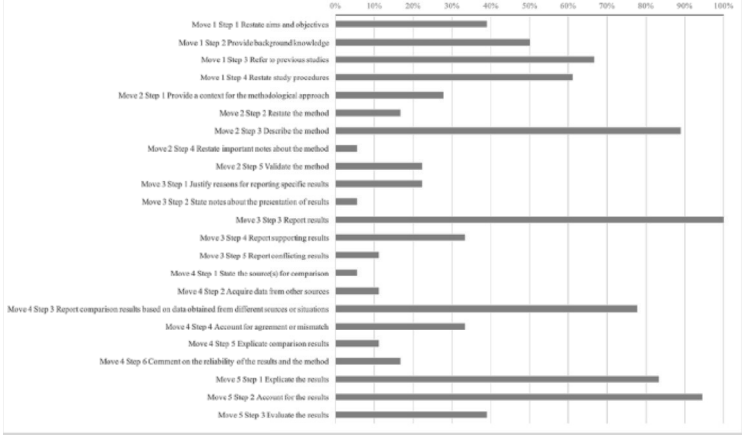

Figure 1. The range of the steps of the most frequent moves (Moves 1, 2, 3, 4 and 5).

Overall, in the Results-Discussion section, researchers remind readers about the contextual information (Move 1) and most importantly the methodological approach (Move 2) to show that the reported results have been achieved in an organised manner. These two moves feature in the majority of the articles. In fact, Move 2 can be merged into Move 1 as they both provide background information to prepare for the presentation of results, and this has been done in many previous move-step schemes (e.g. Yang & Allison, 2003; Basturkmen, 2012; Nordrum & Eriksson, 2015). However, restating various aspects of the methodology emerges as a

prominent feature in the mechanical engineering Results-Discussion texts, and is therefore treated as a separate category.

In Move 1, providing background knowledge without or with citations (Move 1 Step 2 and Move 1 Step 3) together occurs very frequently in the corpus, which is not surprising as new knowledge is cumulatively built on the basis of prior well-established research. Restating study procedures – mentioning key activities in the study (Move 1 Step 4) is also frequent.

> Move 1 Step 2: *Two-phase flow regime is susceptible to inlet flow conditions and is developing along the flow direction.* [EX2]
>
> Move 1 Step 4: *Before examining nanofluids with VG, several tests have been done to compare between the results of* …. [MX5]

In Move 2, describing the methodological approach (Move 2 Step 3) occurs in the majority of the texts, showing that this is a conventional practice in mechanical engineering discourse. Furthermore, ensuring the validation of the method (Move 2 Step 5) before the demonstration of the results, although present only in the MX articles, is a practice that has not been found in the Results/Discussion-Conclusions section of articles in other disciplines. The presence of these communicative functions in the Results-Discussion section suggests that it is important for the mechanical engineering articles to highlight that the results being reported are obtained from a credible, clear method.

> Move 2 Step 3: *In the present experiment, the axial location of flow visualization and inlet conditions were kept constant.* [EX2]
>
> Move 2 Step 5: *The maximum deviation from the numerical results to the experimental ones is within 9.3%, while that from the theoretical results to the experimental ones is within 11.3%, which proves the feasibility and reliability of the theoretical and numerical models.* [MX6]

After providing important background knowledge, mechanical engineering researchers present results to indicate how the study addresses the research problems raised in the previous sections (Move 3). This move occurs in all the articles and takes up nearly half of the text, showing that reporting results is the main function in the Results-Discussion section of mechanical engineering articles.

> Move 3 Step 3: *Specifically, when the location of O2 injection moves outward from the inner ring, the high-temperature zone somewhat moves downstream.* [TH1]

In most of the articles, researchers validate the reported results by directly or indirectly comparing the results of the study with those in the literature or those obtained from different research methods (Move 4). Direct comparisons occur when data obtained from the study and from other sources are visually placed in juxtaposition in tables/figures, while indirect comparisons involve presenting a specific result of the study and then commenting on whether it is similar to or deviant from findings of other studies.

> Move 4 Step 3: *The Akers correlation, however, shows an inconsistent trend when compared to the test data attributed to a singular transition point for the majority of the cases.* [EX5]

Comparing the results of the study with those in the literature is also a conventional practice in the Results/Discussion/Results-Discussion section of research articles in hard sciences like civil engineering and biomedical (Kanoksilapatham, 2015), environmental engineering and chemical engineering (Maswana, Kanamaru, & Tajino, 2015), applied chemistry (Nordrum & Eriksson, 2015), biochemistry (Kanoksilapatham, 2005) and in soft sciences like applied linguistics articles (Pho, 2013). However, the practice of direct comparisons stands out as a distinctive feature in the Result-Discussion section of the mechanical engineering articles, and can relate to the inquiry norms of article types in this discipline, which will be discussed in more detail in sub-section 3.2. Validating the results is also another way of verifying the method in mechanical engineering, especially in MX articles. Based on the results of comparison, researchers indicate the credibility of the method (Move 4 Step 6).

> Move 4 Step 6: *Therefore, the numerical simulation of present work is credible.* [MX2]

It is clear that comparing results in mechanical engineering is not only to strengthen the reliability of the results but also to emphasise the credibility of the method used to obtain the results. The practice of validating the method and the results obtained reflects the epistemological properties of a hard-applied science like mechanical engineering. Mechanical engineering investigates and describes phenomena that are usually complex and abstract

with varying degrees (for example heat transfer within components of a nuclear plant, or air streams). Understandings of these phenomena are gained based mainly on the theoretical and/or experimental examinations under particular assumptions and conditions, of samples or models representing a real-life system with which the phenomena are studied. In order for these insights to be extended into the knowledge of the actual system, the method used and the results obtained must be proved to be trustworthy. Furthermore, results obtained in mechanical engineering research are usually utilized to inform the design and improvement of the system to enhance its applicability. It is therefore important to convince readers of the reliability of the method and the results.

In all the texts, researchers comment on the main findings (Move 5) by interpreting the results (Move 5 Step 1), accounting for the results (Move 5 Step 2) or evaluating the results (Move 5 Step 3). Step 1 and Step 2 occur in the majority of articles, while Step 3 is not common. This finding is also in line with previous move studies (Yang & Allison, 2003; Pho, 2013; Cotos et al., 2016) that found that evaluating results is not as frequent as interpreting results and/or accounting for results.

> Move 5 Step 1: *It is thus recognized that varying oxygen inlet pattern almost has no influence on the performance of coal gasification.* [TH1]
>
> Move 5 Step 2: *That is mainly due to the fact that the surface tension and viscosity of power law fluid in lower shear rate constrains the sheet expansion by damping the inertia force of impinging jet [17].* [EX3]

The current finding that providing background information to prepare for the presentation of results (Move 1 and Move 2), demonstrate results (Move 3), and commenting on the results (Move 5) occur very frequently in the Results-Discussion section of mechanical engineering articles accords with findings of previous studies into Results/Results-Discussion section of articles from other disciplines (e.g. Yang & Allison, 2003; Kanoksilapatham, 2005; Pho, 2013). These functions seem to be universal in academic articles regardless of disciplinary communities.

Before establishing additional research territory, researchers summarise the results (Move 6), but this function occurs in only 1-2 articles. They then evaluate the study (Move 7) in terms of its limitations (Move 7 Step 1) and draw implications in view of the findings (Move 8) by making suggestions (Move 8 Step 1) and outlining future research directions (Move 8 Step 2).

However, these functions are not found to be common in the present corpus. This finding is very similar to that of Cotos et al.'s (2016) study, in which Stating the value, Noting implications and Proposing directions steps were not found to be very common in the Discussion/Conclusions section of the mechanical engineering sub-corpus. In contrast to move/step conceptualisations of similar sections (Results/Discussion-Conclusions) provided in many previous studies, stating significance of the study is not found in the Results-Discussion section of mechanical engineering texts. This is because the significance of the study is often mentioned in the Abstract or near the end of the Introduction section.

It is rather understandable why indicating limitations and suggesting research directions are not common in mechanical engineering articles. Mechanical engineering can be categorised as an urban research domain, in which a large number of researchers are engaged in a small number of research problems (Becher & Trowler, 2001: 106). The competition in mechanical engineering is therefore very intense, and the pace of publication is often very fast. Indicating too many limitations of the research can reduce the chance of being accepted in academic journals. Furthermore, due to the cut-throat competition, mechanical engineering researchers tend to keep to themselves research ideas that can otherwise be lost if shared. They are more likely to make suggestions for further research if they are confident that the proposals can only be fulfilled by their capacity and within their resources. In mechanical engineering, it is more common for researchers to offer suggestions on practical applications.

In addition to the move/step categories, the Results-Discussion section of mechanical engineering articles consists of the "Other functions" category, which includes:

- Define terms – provides definitions of a particular term and can occur whenever a new term is introduced.
- Explain table or figure elements – explains symbols or signs used in tables or figures and occurs when a table or figure is mentioned.
- Locate information – serves as a pointer indicating information and directing readers to relevant parts of the study.
- Announce moves or steps – announces upcoming moves/steps.
- Indicate the structure of the section – announces upcoming sub-sections.

Explain table and figure elements is not found in previous move/step frameworks. It is possible that it belongs to the function of reporting results. Locate information occurs in all the texts. When co-occurring with Report specific results, this function is equivalent to Statement of results in Peng's (1987) framework of moves/steps in the Discussion section of chemical engineering articles, which also occurs almost invariably. This suggests that this function is quite prominent in natural sciences, possibly because constant reference is made to quantitative displays when results are presented. The announcing functions have also been found in previous studies, but received various treatments. Some studies (e.g. Yang & Allison, 2003) include them in the framework of communicative functions. In other studies (Brett, 1994; Jin, 2016), they are treated as a separate category called *metatext*. We follow the second convention as segments of this type do not contain new propositional meanings, but signal the meanings in the upcoming discourse.

3.1.2. Cyclical patterns

Most of the moves and steps are highly recycled, as indicated by the average number of occurrences that is greater than 1.0 (Table 4). The cyclical nature in article sections is also found to be very common in previous move studies (e.g. Holmes, 1997; Peacock, 2002; Yang & Allison, 2003). However, some differences can be observed in terms of the number of occurrences and patterns of co-occurrence between the mechanical engineering texts and those in other disciplines.

All the frequent moves in the present corpus have a higher number of occurrences than those in Yang and Allison's (2003) Results/Results-Discussion section of applied linguistics articles. Most notably, reporting results and commenting on the results (interpreting, accounting for, comparing, and evaluating the results) occur 33.1 and 22 times per section in the mechanical engineering corpus, while these moves have an average of 7.9 and 5.0 occurrences in the applied linguistics corpus. These two practices also occur less frequently in other engineering disciplines examined in Maswana et al.'s (2015) study, with an average of 16.7 and 8.1 times in chemical engineering; 11.4 and 9.3 in environmental engineering; 5.3 and 6.0 in electrical engineering; 1.4 and 2.3 in structural engineering; and 1.3 and 1.7 in computer science Results texts.

The difference is apparently more pronounced between mechanical engineering and applied linguistics. Although this striking difference could

be due to many factors such as the segmentation protocols and the length of the section involved, it would suggest that the mechanical engineering Results-Discussion section is more complex in terms of move structure than the applied linguistics Results/Results-Discussion section. The former presents results in more detail, puts more efforts into establishing their meanings, provides more explanations for the results, and compare them with the literature. The comparisons with the other engineering disciplines however show a mixed result: the distinction is less marked between mechanical engineering and chemical/environmental engineering, but more discernible between mechanical engineering and electrical/structural engineering, computer science. It would be a challenge to interpret the differences between mechanical engineering and other engineering disciplines, due to the difference in the sections being examined and especially lack of information about which unit of analysis and realisation was used to identify the moves and steps in Maswana et al.'s (2015) study.

The cyclicality of the moves and steps leads to the formation of patterns of co-occurrence. The present corpus has an average of 15.4 cycles per section, which is significantly greater than the means in Holmes's (1997) corpus of political science and sociology articles (3.5 and 2.7). It must be emphasised again that the comparison is relative as the number of cyclical patterns depends on frameworks of analysis and the corpus size. It seems, however, that the Results-Discussion section of hard applied sciences like mechanical engineering is more complex than the social science Discussion texts.

Altogether, we can draw a tentative conclusion that the Results-Discussion section of hard sciences like mechanical engineering has higher complexity than soft sciences such as applied linguistics, political science, and sociology, with significantly more occurrences of moves/steps and greater numbers of cyclical patterns. It is possible that such disciplinary variation reflects the nature of mechanical engineering discourse, which often involves thick and detailed descriptions of complex processes and behavior. Greater numbers of move/step occurrences and cycles identified in the present study may also highlight the role of the segmentation scheme, which allows multilayer coding at the sentence level and a range of grammatical units conveying rhetorical functions, in disentangling the complexity and subtlety in the way the Results-Discussion is structured in the mechanical engineering texts.

3.1.3. Intradisciplinary varation

Table 5 presents the number of occurrences of the most common and extensive moves and their constitutive steps. The information provided is used to, rather than quantify differences given the limited amounts of data, decide where to look for possible variation in the way knowledge is constructed in different types of article in mechanical engineering. Articles using different research methods are most noticeably differentiated in terms of how the method used and the results obtained are validated in the Results-Discussion section, as shown in the profile of Move 2 and Move 4, more particularly in Move 2 Step 5 Validate the method, Move 4 Step 3 Report comparison results based on the data obtained from different sources or situations, and Move 4 Step 6 Comment on the reliability of the results and the method.

In the Results-Discussion section, MX articles validate the method, while this function is rare in the EX and TH articles. MX articles adopt two main ways to ensure that the results are reliably obtained from credible methods. One is to devote a sub-section to validating the method (Move 2 Step 5) before the demonstration of the results. The other involves directly comparing data obtained from different methods/studies (Move 4 Step 3), and then explicitly indicate the reliability of the method (Move 4 Step 6). The presence of these communicative functions in MX articles ties in with one of their main objectives, which is to cross-validate the methods (experimental and theoretical) and prove the workability of the triangulation approach. In contrast, EX and TH articles do not validate the method in a separate sub-section in the Results-Discussion section; nor do they state its credibility. One possible reason is that validating the method is not part of the research aims that EX and TH articles need to fulfil, and thus the Results-Discussion section is not an appropriate place for method verification. In fact, nearly all of them validate the method in the preceding section – Methods. In general, most MX articles verify the method in the Results-Discussion section, while EX and TH articles typically do this in the Methods section.

Articles employing different methods also differ in the way they validate the results (Move 4 Step 3). Most MX articles directly compare data, while EX and TH articles tend to make indirect comparisons. This can be explained by the characteristics of each research paradigm. MX articles need to present results obtained from two different methods, and therefore they compare

results directly by placing together two sources of data. In contrast, EX and TH articles contain data acquired from one method, either experimental or theoretical, so they are more likely to present their results and compare them with those in the literature. It is noted, however, some EX and TH articles also directly compare results to verify their data. Two EX articles (EX2 and EX5) make direct comparisons of data because they describe complex processes, and agreement or deviation is more easily revealed and observed when different sets of data are visually presented. In addition, two TH articles (TH2 and TH4) directly compare different sources of data, and indicate whether their data are supported with evidence, because it is through this practice that they claim the reliability of the method that has not been validated in the Methods section.

Communicative functions		MX (relative mean)	EX (relative mean)	TH (relative mean)
Move 1	Step 1	0.85	0.1	0.4
	Step 2	0.3	2.6	0.4
	Step 3	0.85	2.7	1.05
	Step 4	1.05	1.2	0.8
Move 2	Step 1	0	0.85	2.65
	Step 2	0.1	0.25	0
	Step 3	1.4	2.45	2.15
	Step 4	0.2	0	0
	Step 5	6.25	0	0
Move 4	Step 1	0	0.1	0
	Step 2	0	1.4	0
	Step 3 (Direct comparison)	2.45	3.35	1.4
	Step 3 (Indirect comparison)	0.5	1.9	1.1
	Step 4	0.65	1.15	0
	Step 5	0	0.3	0
	Step 6	0.45	0	0
Move 5	Step 1	2.4	0.95	3.95
	Step 2	6.3	7	5.85
	Step 3	0.45	0.3	0.25

Table 5. The number of occurrences of the steps of Moves 1, 2, 4 and 5.

4. Conclusions

The present study identifies the move structure of the Results-Discussion section of mechanical engineering academic articles. An analysis of the whole article would obviously help interpret move/step results more accurately as there is an inter-relationship of rhetorical structures in different article sections. This small-scale study provides an insight into mechanical engineering academic discourse by exploring shared and differential textual features within this discipline, and thus makes an addition to genre-based

studies that have been conducted in a range of disciplines, and further extends this extant body of research within an under-studied discipline like mechanical engineering. The prototypical rhetorical structure of and move/step-related phenomena identified in the Results-Discussion section of the mechanical engineering articles that use different research methods share several features with those in other disciplines, but also contain many rhetorical functions and strategies characteristic of knowledge-making practices inherent in the mechanical engineering field.

Overall, in the Results-Discussion section, mechanical engineering researchers tend to emphasise the validity of the methodological approach used to obtained the results in their studies and the vigour of their results. The present study has highlighted subtle intra-disciplinary variation; in more particular, the articles using different research traditions have distinctive ways of verifying the methods and results reported. The findings also point to interdisciplinary variation, most notably between mechanical engineering and the soft science fields in terms of the organisational complexity. Variation between mechanical engineering and other engineering fields has also emerged. It should be stressed however that the conclusions drawn from these interdisciplinary differences should be treated as suggestive in nature as they have been observed based on the comparisons of the data sets that are not very compatible in certain respects or lacking in critical information such as the corpus sizes, the sections being analysed, the coding schemes adopted, and the move/step label definitions.

The findings have several implications. First, genre analysis can be carried out at different levels if more subtle differences are to be uncovered. Second, the finding on the genre variation within a single discipline highlights the importance of balancing components in a corpus for genre analyses. Many of the genre-based studies have examined corpora consisting of a certain number of articles in a particular discipline. It remains an open question as to whether these corpora take into consideration other important discipline-related factors such as research types and sub-disciplines that, as is evident from the present study, contribute to variation within the discipline. The third implication is that coding below the sentence level and keeping the unit of realisation open to meaningful units in any grammatical form is important for the identification of more subtle rhetorical functions, since it has been shown that the current scheme is able to capture communicative functions in the mechanical engineering texts that may be ignored in previous frameworks. Finally, genre-based research investigating discipline-specific

structural features like the present study can provide a useful resource for producing pedagogical activities for writing instruction in specific disciplines to help raise students' awareness of typical rhetorical norms as well as possible variation.

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Appendix

Article code	Article information
MX1	Shokouhmand, H., & Zareh, M. (2014). Experimental investigation and numerical simulation of choked refrigerant flow through helical adiabatic capillary tube.
MX2	Wang, J., Ma, H., Zhu, Q., Dong, Y., & Yue, K. (2016). Numerical and experimental investigation of pulsating heat pipes with corrugated configuration.
MX3	Malekshah, E. H., & Salari, M. (2017). Experimental and numerical investigation of natural convection in a rectangular cuboid filled by two immiscible fluids.
MX4	Longeon, M., Soupart, A., Fourmigué, J.-F., Bruch, A., & Marty, P. (2013). Experimental and numerical study of annular PCM storage in the presence of natural convection.
MX5	Ahmed, H. E., Ahmed, M. I., & Yusoff, M. Z. (2015). Heat transfer enhancement in a triangular duct using compound nanofluids and turbulators.
MX6	Xiao, X., Zhang, P., Shao, D. D., & Li, M. (2014). Experimental and numerical heat transfer analysis of a V-cavity absorber for linear parabolic trough solar collector.
EX1	Zhao, G.-y., Li, Y.-h., Liang, H., Han, M.-h., & Hua, W.-z. (2014). Control of vortex on a non-slender delta wing by a nanosecond pulse surface dielectric barrier discharge.
EX2	Takamasa, T., Hazuku, T., & Hibiki, T. (2008). Experimental study of gas–liquid two-phase flow affected by wall surface wettability.
EX3	Ma, Y.-c., Bai, F.-q., Chang, Q., Yi, J.-m., Jiao, K., & Du, Q. (2015). An experimental study on the atomization characteristics of impinging jets of power law fluid.
EX4	Dannemand, M., Johansen, J. B., Kong, W., & Furbo, S. (2016). Experimental investigations on cylindrical latent heat storage units with sodium acetate trihydrate composites utilizing supercooling.
EX5	Ghim, G., & Lee, J. (2016). Experimental evaluation of the in-tube condensation heat transfer of pure n-pentane/R245fa and their non-azeotropic mixture as an ORC working fluid.
EX6	Okello, D., Foong, C. W., Nydal, O. J., & Banda, E. J. K. (2014). An experimental investigation on the combined use of phase change material and rock particles for high temperature (~350 °C) heat storage.
TH1	Chen, C.-J., Hung, C.-I., & Chen, W.-H. (2012). Numerical investigation on performance of coal gasification under various injection patterns in an entrained flow gasifier.
TH2	Lin, W., Feng, Y., & Zhang, X. (2015). Numerical study of volatiles production, fluid flow and heat transfer in coke ovens.
TH3	Ireka, I. E., & Chinyoka, T. (2013). Non-isothermal flow of a Johnson–Segalman liquid in a lubricated pipe with wall slip.
TH4	Hosain, M. L., Bel Fdhila, R., & Daneryd, A. (2016). Heat transfer by liquid jets impinging on a hot flat surface.
TH5	Deng, Z., Hui, K., Zhang, Y., & Cao, Y. (2016). Numerical simulation analysis of the flow field and convective heat transfer in new super open rack vaporizer.
TH6	Jiang, C., Shi, E., Hu, Z., Zhu, X., & Xie, N. (2015). Numerical simulation of thermomagnetic convection of air in a porous square enclosure under a magnetic quadrupole field using LTNE models.

Table 6. List of the mechanical engineering research articles used for move analysis.