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Rhetorical structures and linguistic mechanisms in English-language industrial engineering research article introductions

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Abstract

The purpose of this research is to examine RAIs written for industrial engineering (IE) articles from a rhetorical and organizational perspective. We manually annotated the motions and stages based on the framework developed from Swales' (1990, 2004) CARS model and prior research. Forty RAs were selected from the top-class English journals in this academic community. According to the findings, IE RAIs adhere to the CARS model for the three required movements, with minor variations in the particular stages of the third move. Additionally, the results improve the prospects of IE practitioners in editing or composing RAs that adhere to their academic conventions, and they add to the body of knowledge on how to modify the generic CARS model to better equip teachers for research and teaching that is genre-based in academic writing.

Keywords: Academic writing, Communicative purpose, Linguistic mechanism, Move analysis, Rhetorical structure.

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1. Introduction

Researchers and academics at all levels are under increasing pressure to produce high-quality research articles (RAs) and submit them to prestigious journals in order to further their careers in academia. Researchers have examined the structure of RAs as a whole and how their various sections are organized. For example, the Abstract section (e.g. [1-4]), the Introduction section (e.g. [1, 2, 5-8]) the Method section [9-11] the Results section (e.g. [12-14]) and the Discussion section (e.g. [15, 16]).

The introduction section of RAs has been extensively studied for the longest time and by the most researchers [1, 17-30]. Both native and non-native scholars agree that this section is the most difficult [31] and "troublesome" [2]. Since its proposal by Swales [2] on ESP-based genre analysis of the introduction part, the CARS (Create A Research Space) model has been used as a benchmark for RA introduction writing and instruction. Linguists like Hyland [32], Swales and Feak [19] and Swales and Feak [20] and others have argued for the use of genre-analysis tasks in teaching and learning RA writing, especially for non-native speakers. This is due to the fact that RA writing aims to achieve specific goals with elements that

emphasize lexico-grammatical features, organization, communicative function, or disciplinary conventions. As a result, there are strong correlations between the structure of a text and its communicative effectiveness [8]. Therefore, it is beneficial for learners to have a deeper understanding of RAs in a particular field. This will help them become more aware of writing conventions and ultimately produce texts that meet the standards of their academic and professional discourse communities in terms of language and organization.

Therefore, the rhetorical and organizational structure of the research article introduction (RAI) has been the primary focus of applied linguistics scholars for the last 30 years [8].

Genre analysis, or variations in RAI, has been the subject of a great deal of research in many fields, including: engineering [33, 34] agricultural science [35] chemistry [36] applied linguistics and psychology [37] management [23] education [38] forestry [8] laws [39] discrete mathematics [40] etc.

Engineering encompasses a wide range of sub-disciplines, including chemical, civil, mechanical, electrical, industrial, and many more [41] as cited in [34]. Software, civil, and biological engineering have been the primary areas of study in the past [5, 34]. Although Industrial Engineering (IE) is vital in the real world due to its emphasis on solving practical problems in various areas of industrial development and in our everyday lives, the researcher is unaware of any of the aforementioned studies that have concentrated on IE's movement analysis.

Therefore, this study aims to investigate the rhetorical structure and the linguistic mechanisms of IE RAIs, with the hope of creating a feasible pedagogical model for the students and scholars in this engineering sub-discipline. The study designates four specific research focuses, i.e., *Science and Technology of Weapons, Science and Control of Weapons, Control Theory and Control Science, and Information and Communication Engineering* as the representatives since the majority of students in the researcher's academic writing class are conducting research in these four aspects. The study hopes to provide a head start for IE students, researchers, and scholars in fulfilling their tasks of RA writing/reading in their disciplinary discourse.

2. The Research Background

In 2020, a university in China carried out a teaching reform for postgraduate education, and English is a compulsory course for postgraduate students. The doctoral students have passed Band 6 (the most rigorous English proficiency exam required of Chinese college students whose majors do not include English) and they are required to publish and share their research discoveries in international SCI-based journals before graduation. Thereby, they need to master the writing practices of their international academic community, which is not only essential for their academic achievements but also for future career development. Under this situation, the researcher applied for opening a course, namely, "Writing and Publishing Scientific and Technical English Papers in International Journals" for doctoral students, and admission was undoubtedly granted. In the fall semester of 2020, the course was successfully started. The total number of Ph.D. students who were required to take one of two compulsory English courses is 90, and the number of students who took this course was 80, accounting for 90% of the total number of students, indicating a strong demand from students for English journal paper writing and publishing skills.

3. Corpus Compilation and Genre Analysis

3.1. Journals Selected

Unlike software engineering, civil engineering, and biomedical engineering, industrial engineering, which plays an indispensable role and is widely applied in various aspects of the real world, is not as common a discipline in some higher learning institutions as in others. Hence, it is receiving little attention, probably due to its complicated branches and the slim chances linguistic researchers have to read RAs on it. Since IE is regarded as a core discipline at the researcher's university and the number of students majoring in it is large, the researcher has both the opportunity to learn about it and the commitment to analyzing and instructing the organizational and rhetorical features of the RA introductions in this sub-discipline to ensure that the students are well prepared with the writing practice of IE RAIs and capable of writing a good one.

Based on the students' own sub-disciplines and their degree advisors' suggestions and recommendations, the present study designates eight high-impact industrial engineering journals, namely IEEE Transactions on Automatic Control, with an impact factor of 5.625, Automatica,5.541, IEEE Transactions on Neural Networks and Learning Systems, 8.793, IEEE Transactions on Image Processing, 9.34, IEEE Transactions on Signal Processing, 5.028, IEEE Transactions on Information Forensics and Security, 6.013, IEEE Transactions on Circuits and Systems, 2.814, and the Journal of the Franklin Institute, 4.036 as the corpus source. These eight journals address a broad range of issues in industrial engineering and associated disciplines.

3.2. Ras Selected

Forty RAs issued between 2019 and the middle of 2021 were included in the research. A corpus of forty RAs seems sufficient to enable a critical genre study of the articles' organizational structures and communicative goals, given that quantitative analysis was not the aim [42]. The students obtained the RAs by either typing in the keywords related to their major in the search engines or following their degree advisors' suggestions and recommendations. We did not utilize the authors' L1 status as an inclusion criterion while compiling the corpus since the rigorous peer review or editing processes of the world's major journals could dependably ensure that the published RAs met the rhetorical and linguistic standards [43]. Furthermore, in the process of article selection, in order to avoid any bias in the introduction selection, students are not allowed to read through the whole paper in detail, particularly the introduction. They instead only read the abstracts thoroughly to ensure that all the articles chosen are closely related to their majors, thus fully exerting the implications of move analysis. The RAs chosen, however, have to display a literal macro-structure or a functional macrostructure of Abstract-

Introduction-Method-Results-Discussion-Conclusion [44], which is considered to be the standard form to report original research and discoveries [45] and were used as the authentic corpus to which the course lectures would refer.

The study must ensure that the selected articles are closely related to the students' major so that they will benefit most from the move analysis in the following two essential aspects: improving their professional knowledge, being one, and advancing their writing skills for publishing in international journals, being the other. As a result, there is an uneven number of articles from each journal, varying from a minimum of 1, as is the case with IEEE Transactions on Circuits and Systems, the Journal of the Franklin Institute, and IEEE Transactions on Information Forensics and Security, to a maximum of 15, as is the case with Automatic.

3.3. Genre analysis

A "move" is defined as a "discoursal" or "rhetorical unit" that serves a "coherent communicative function" in any kind of discourse, whether it's written or spoken, according to Swales' genre analysis [1, 2]. Swales suggests the CARS framework [1, 2] for RA introduction move analysis based on his research. There are three required steps in the model: step one, which involves establishing a territory; step two, which involves creating a niche; and step three, which involves occupying a niche. Later research by Anthony [5], Lewin et al. [28], Dressen and Swales [46] and Samraj [6] confirmed the presence of disciplinary variation in RA introduction writing, providing strong support for Swales' adjustment of the Swales [1] CARS model. Swales consolidated two phases in Move 1 ("Topic generalizations of increasing specificity") into one in the 2004 edition, eliminating the need to assess prior research Swales [2]. Two steps, "indicating a gap" and "adding to what is known," replaced the four realizations in Move 2—step 1a "counter-claiming," step 1b "indicating a gap," step 1c "question-raising," and step 1d "continuing a tradition." Additionally, a new optional step 2 called "presenting positive justification" was added. In contrast to the first three stages, which were as follows: "Implementing the purpose and stating the purpose of the present research (obligatory)"; "Announcing principal findings (optional)"; and "Indicating the structure of the paper (optional)" There are seven steps in the third move in the 2004 version, as opposed to two in the 1990 version. (It is required that the research be presented in a descriptive and/or meaningful way. It is not required that you provide research questions or theories. 3. It is not necessary to clarify definitions. 4. Summing up procedures is not required. Fifth, you must announce the primary outcomes (PISF). 6. The expression of the current research's value (PISF) is discretionary. 7. Creating a framework for the paper is not required.)

On the basis of Swales [2] model and the previous studies on Engineering RA introductions [27, 34, 43] the framework for this study is shown in Table 1.

Table 1.
Adapted analytic framework for this study.

Move	Step Tagging	Category
Move 1 Setting upon a domain	Step 1 M1-S1a	Taking center stage
	Step 2 M1-S2	Generalizing on a subject
	Step 3 M1-S3	Examining aspects of prior studies
Move 2 Creating a specialization	Step 1a M2-S1a	Pointing to a void
	Step 1b M2-S1b	Expanding upon existing knowledge
	Step 2 M2-S2	Providing convincing evidence
Move 3 Exhibiting the current	Step 1 M3-S1	Reporting about ongoing studies in a descriptively or purposeful manner
	Step 2 M3-S2	Explanation of term
	Step 3 M3-S3	Reviewing procedures
	Step 4 M3-S4	Describing a mathematical farmwork
	Step 5 M3-S5	Highlighting the significance of the current study
	Step 6 M3-S6	Justifying the emphasis and methodology of research
	Step 7 M3-S7	Providing updates and debating outcomes
	Step 8 M3-S8	Constructing an outline of RA

3.4. Genre-Analysis Sample Preparation

Once the articles are identified, the language instructor with extensive knowledge of genre analysis then teaches students the necessary genre knowledge about the introductory section, e.g., the composition of the steps and the linguistic markers or indicators used to achieve each step and move in order to tag the moves and steps in the introduction.

Then both the instructor and the students do step tagging to the two RAs designated out of the 10 RAs each individual student provided. To clarify, at this stage, each student will only analyze the two RAs selected by the instructor on their own paper list, but the instructor will tag 8 in total with 2 from each list of 10 RAs the four students have provided. Afterwards, both the language instructor and the students demonstrated their introduction genre analysis samples. Disagreements were discussed and distinguished from misidentifying genre items showing designated rhetorical and organizational functions and confusing professional justification for certain expressions. In the former, the language teacher would stress the link between linguistic cues and their rhetorical and structural purposes.

For example, when exemplifying ways of establishing the niche (Move 2), the language teacher would underscore typical linguistic features such as *'none', 'few', 'rarely', 'seldom', 'little', 'not', 'yet to', 'mixed evidence', 'ambiguity', 'a lack of consensus', 'inconsistent findings', 'debate in the literature', 'fail to'*, *etc.*, to indicate a gap [23, 40]. Therefore, the students

will clarify the techniques and linguistic markers conventionally used by other authors to establish Move 2. If the disagreement entails professional knowledge or scientific community conventions, then the instructor would ask the students to seek clarification from their degree advisors to provide a reasonable and academic explanation for the division from a professional perspective. In this way, students have a comprehensive understanding of genre analysis and a full grasp of the linguistic features that are used to realize the function of the speech step, laying a solid foundation for improving the accuracy of the analysis.

Based on the instructor's instructions and illustrations, each student then finished analyzing the rest of the RA introductions they had selected and summarized the moves and steps. In the meantime, the instructor also conducted move analysis on all 40 chosen articles, and as mentioned above, disagreement is frequently debated between the instructor and the students, and with the degree advisors if necessary. It is after 8 (with even more for certain articles) rounds of tagging and retagging that the final determination for the moves and steps of the 40 articles is made.

4. Results and Discussion

4.1. Moves and Steps

This study followed previous criteria for move and step classification [8, 47, 48] which considered a move 'obligatory' when it shows 100% occurrence, 'quasi-obligatory' when the frequency is between 51% and 99%, and 'optional' when it appears in 50% or less of the total. Studying the materials with the goal of identifying the lexico-grammatical includes of each rhetorical step—including phrase types, word choice, or grammatical features like tenses and voices used—followed the researcher's generalization of the moves and steps [49].

Table 2 shows the move sequence & the total amount in move units in each RAI. The results show that the IE RAIs move structures are significantly compatible with the CARS model. The three steps of the CARS model are present in all forty RAIs of the corpus [1, 2]. On the other hand, the move sequences utilized in IE RAIs reveal that, on one hand, the 'M1, M2, and M3' sequence is not always followed in IE RAIs and on the other hand, cyclic structuring, with the M1-M2 pattern in particular, is not commonly observed in IE RAIs. Almost all RA introductions open with Move 1, except in two instances (ZRA5 & ZRA10 from Automatica) both of which open with Move 3-S1. Move 3 is unanimously the closing move in the entire corpus, but the number of RAIs that develop from Move 1 to Move 3 directly is only 8 (20%), which is consistent with previous studies [8]. The majority of them show varying degrees of cyclic occurrence, with the M1-M2-M1-M2-M3 structure having the highest frequency, accounting for 27%. A variety of move structures such as M1-M2-M1-M3-M1-M3-M1-M2-M3 (DRA7), M1-M2-M3-M1-M3-M1-M2-M3 (DRA8), M1-M2-M3-M1-M2-M3 (HRA6), *etc.*, have been observed. The commonest cyclic pattern is the 'M1-M2' sequence, which is either in continuous round or being interrupted by other pairs of moves observed in 24 out of the 40 RAIs, constituting 55%, which is slightly lower than previous studies [8].

In one case (SRA1), 9 cycles of the 'M1-M2' sequence is identified. In contrast, 'M1-M3' (SRA9&DRA3) and 'M3-M1' (DRA8, ZRA5) cycles appear in only two RAs respectively.

4.2. Move 1 Establishing Territory

Move 1 is obligatory in IE RAIs, and it is realized through three steps, i.e., M1-S1 (asserting one's dominance), M1-S2 (generalizing about a subject), and M1-S3 (perusing elements from prior studies), each of which shows a staggeringly high percentage of occurrence, being 97.5%, 95%, and 100%, respectively, much larger than in other disciplines and other sub-engineering disciplines [8, 34]. The high rate of presence of each step in IE is more likely due to its well-established research status.

4.2.1. Claim Centrality

The goal of claiming centrality is to persuade the academic community of the topic's or research's importance or urgency. Industrial engineering RAs often highlight the importance of the problem or technology being studied both in terms of the phenomenal world (e.g., '*widely used and developed*', '*widespread applications*', '*plays an important role in practical applications*', *etc.*) and the epistemic world (e.g., '*has been heavily researched*', '*has been an active field of study*', and '*has emerged as a major hub for academic inquiry*', *etc.* (See examples 1, 2, 3, 4). In many cases, researchers in IE RAIs tend to incorporate the two aspects into one sentence ('*… has drawn notable attention from researchers in different fields and played an important role in practical applications…*' (See examples 2 and 4). Locative adverbials (e.g., '*in*', '*for*', *etc.*) highlight the specific regions in the real world where the present technology has been widely used or needed. The logic connector '*due to*' prevails in most of the centrality claim sentences to incorporate both the importance in the real world and that in the research area into one sentence. Centrality is largely maintained with particular usage of adjectives (e.g., '*essential*', '*fundamental*', '*serious*', '*significant*', '*active*', *etc.*), adjectives indicating importance (e.g., '*potential*', '*growing*', '*increasing*', '*considerable*', *etc.*), and adverbs ('*extensively*', '*widely*', *etc.*) showing the range of application. The following are a small number of illustrations (See examples 1-4 in appendix 1).

The predominant tense employed is the present perfect, and phrases such as '*over the past decades*' and '*in recent years*' constitute a dominant feature indicating that the topic being discussed is well established, arousing wide attention and boasting a long history.

4.2.2. Exploring Broad Themes and Synthesizing Existing Literature

Topic generalization, which occurs in 38 out of the 40 RAIs, generalizes the cutting-edge approaches/methods, algorithms, control protocols, *etc.*, used in the real world or by the research community in IE for the time being, or being the focus of previous research (See examples 5 and 6). As Samraj [6] claims that in most cases there is no clear demarcation between M1-S2 (topic generalization) and M1-S3 (reviewing items of previous research), which is particularly true in IE RAIs (Example 5 in appendix 1)

4.3. Move 2 Establishing the Niche

Move 2 is quasi-obligatory in IE RAIs, showing an occurrence of 95% (38 RAs) much higher than in other engineering sub-disciplines [34]. Of all the 38 RAs containing M2, M2-S1 (indicating a gap) was found to showcase a 95% presence. M2-S2 (adding to what is known) was much less frequent (only 25%), similar to other engineering sub-disciplines [34]. M2-S3 (presenting positive justification) occurs in 21 (about 53%) of all IE RAs, much higher than in other engineering RAIs [34]. The higher frequency of Move 2 and the specific steps in IE is likely due to its problem-solving feature [50] tending to advance and invent novel, better, more effective, and economical algorithms, methods/approaches, and protocols, *etc.*, to solve practical problems in the real world.

4.3.1. Pointing To a Void

According to Lim [23], there are four distinct ways in which writers highlight a void in earlier research, of which "revealing a limitation in previous research" is the most preferred in IE RAIs, with only a few occasions when researchers supplement limitations with insufficient previous studies (See Example 13). Frequently, researchers in IE tend to point out limitations in previous studies by using expressions such as "*only focus on*", "*may not be adequate*", "*drawback*", "*not efficient*", "*not able to*", "*…are assumed to be*", *etc.*, which are usually preceded by the contrastive word "*however*" (See examples 7-12, in appendix 1).

4.3.2. Adding to What is Known

"Adding to what is known" shows a lesser occurrence (10 (about 25%)) in IE RAIs, close to that in Biomedical Engineering [34]. Typical linguistic indicators are "*preserving*", "*further address*", "*extend*", "*broaden*", *etc.*, which are partially illustrated in examples 14 and 15.

4.3.3. Providing Convincing Evidence

Presenting positive justification was used 52.5% in IE, again much higher than in other engineering RAs [34]. Researchers endeavor to convince others of the demerits existing in the previous systems, methods, algorithms, *etc.*, and the reasons why the projected research is needed. To justify the necessity for the present study, logical connectors such as "*however*", "*in order to*", "*thus*", "*on the other hand*", "*therefore*", *etc.* are frequently used. On the one hand, and on the other, expressions that illustrate the limitations in previous research and the advantages of the current one are widely applied, for example, "*can no longer be used*", "*save computational resources*", "*highly desirable*", "*is not possible*". Additionally, adverbial phrases such as "*in real applications*", "*when*", "*in the absence of*", "*under such circumstances*", *etc.*, are also used to indicate the exact situation where the feasibility of the previous work is impossible.

Table 2.
Move structure in IE RA introductions.

Move structure in IE RA introductions	Number of Articles 40	100 %
Articles following Swales' CARS model	28	70
M1–M2–M3	8	20
M1–M2–M1–M3	2	5
M1–M2–M1–M2–M3	7	17.5
M1-M2-M1-M2-M1-M3	1	2.5
M1–M2–M1–M2–M1–M2–M3	3	7.5
M1–M2–M1–M2–M1–M2–M1–M3	1	5
M1–M2–M1–M2–M1–M2–M1–M2-M3	3	7.5
M1-M2-M1-M2-M1-M2-M1-M2-M1-M2-M3	3	7.5
Articles deviating from the strict Swales' CARS model	12	30
M1-M3-M1-M3	2	5
M1–M2–M3–M1–M2–M3	1	2.5
M1-M2-M1-M3-M1-M2-M3	1	2.5
M1–M2–M1–M2–M3–M1–M3	1	2.5
M1–M2–M3–M1–M3–M1–M2–M3	1	2.5
M1–M2–M1–M2–M1-M3–M1–M2-M3	1	2.5
M1–M2–M1–M3–M1-M3–M1–M2-M3	1	2.5
M1–M2–M1–M2–M3-M3–M1–M2-M1-M2-M3	1	2.5
M1-M3- M1-M2-M1-M2-M1-M2-M1-M2-M1-M2-		
M1-M2-M1-M2-M1-M2-M1-M2-M3	1	2.5
M3- M1-M2-M1-M2-M1-M2-M1-M2-M3	1	2.5
M3- M1-M2-M1-M3-M1-M2-M1 -M3	1	2.5
Total number of articles	40	100
M1: Establishing a territory; M2: Establishing a niche; M3: Occupying the niche.		

Table 3.
Textual structure and organization of introductions in industrial engineering (N =40).

Move Move 1	Step Tagging	Category Establishing a territory	No. of Articles 40	% 100a
	Step 1 M1-S1	Taking center stage	39	97.5b
	Step 2 M1-S2	Generalizing on a subject	38	95 b
	Step 3 M1-S3	Examining aspects of prior studies	40	100a
Move 2		Establishing a niche	38	95 b
	Step 1a M2-S1a	Pointing to a void	38	95 b
	Step 1b M2-S1b	Expanding upon existing knowledge	10	25c
	Step 2 M2-S2	Providing convincing evidence	21	52.5b
Move 3		Presenting the present work	40	100 a
	Step 1 M3-S1	Reporting about ongoing studies in a Descriptively or purposeful manner	40	100 a
	Step 2 M3-S2	Explanation of term	3	7.5c
	Step 3 M3-S3	Reviewing procedures	15	37.5c
	Step 4 M3-S4	Describing a mathematical farmwork	31	77.5 b
	Step 5 M3-S5	Highlighting the significance of the current study	19	47.5 c
	Step 6 M3-S6	Justifying the emphasis and methodology of research	29	72. 5 b
	Step 7 M3-S7	Providing updates and debating outcomes	2	5 c
	Step 8 M3-S8	Constructing an outline of RA	27	65 b
	Step 9 M3-S9	Laying down mathematical symbols	14	35

Note: a: obligatory; b: quasi-obligatory; c: optional.

4.4. Move 3 Presenting the Present Work

Evidence from wildlife behavior shows that Move 3 is common in the vast majority of IE RAIs [6]. Civil engineering RAIs [34, 51] and Environmental Science RAIs Kanoksilapatham [34] and Kanoksilapatham [51]. Joseph et al. [8]. There is a total of 9 phases that have been found, with the likelihood of occurring ranging from 2.5 percent to 100%. In the following steps, those that present less than 10% (including) are not exemplified since they are not considered a distinct feature in IE RAIs.

4.4.1. M3-S1 (Reporting About Ongoing Studies in a Descriptiveand/Or Purposeful Manner)

In Move 3, M3-S1 is obligatory, occurring in all 40 RAs. While this occurrence is equivalent to that observed in Wildlife Behavior [6], it is different from the presence of this frequency in the other three Engineering sub-disciplines, where the greatest presence is 83.05 [34]. Several linguistic features are frequently seen, which are (i) infinitive structures (e.g., "*to*" and "*in order to*", *etc.*) often used with reporting verbs (e.g., "*propose*", "*formulate*", *etc.*), (ii) noun phrases referring to the study (e.g., "*this work*", "*this paper*", *etc.*), (iii) prepositional phrases like "*in this paper*", "*in this work*", *etc.*, and (iv) attributive sentences preceded by "*which*", "*that*", "*where*" or restrictive modifiers introduced by, for example, "*with*", "*by*", "*for*", *etc.*, to elaborate on the unique scenarios that the presented protocols, algorithms, *etc.*, will function in, which previous research, instead, falls short of. The simple present tense seems predominant, whether in active voice or passive voice.

4.4.2. M3-S2 (Definitional Clarification)

The observation reveals that researchers in this sub-discipline seldom clarify definitions (seen only in 3 RAs (7.5%)). The followings are two samples (examples 25 and 26, in appendix 1).

4.4.3. M3-S3 (Summarizing Methods)

The researcher of this study finds that it is difficult to distinguish M3-S3 from M3-S5 (Rationalizing research focus and design) in IE RAIs. To clarify, in this paper, M3-S3 is identified when it appears as only a list of methods or procedures without any justification. In this way, 15 (37.5%) is identified, which seems to occupy a much lower percentage than in other engineering sub-disciplines [34]. However, it should be noted that it is common in IE RAIs that M3-S3, M3-S4, and M3-S5 are usually heavily overlapped and interwoven, making it hard to separate one from the others. If the result includes methods integrated into contributions and rationalizing design and focus, then M3-S3 will show a higher rate of frequency. The location of M3-S3 also turns out to be flexible.

This move is characterized by such method-related nouns as "*methodology*", "*algorithms*", "*controllers*", "model", "*framework*", *etc.*, procedural verbs (e.g., "*design*", "*employ*", "*present*", "*propose*" and "*introduce*"), and sequential words (e.g., "*first*", "*second*", "*then*", etc.). And as in other fields [6] In IE RAIs, writers have a proclivity to employ the first-person pronoun 'we' in the sentence-subject position and the present simple tense. Like the convention in Method sections, the passive structure far outnumbers the active one as illustrated in (examples 27-30, in appendix 1).

These noteworthy statistical distinctions serve to emphasize the relevant features of this field of study. In particular, the fact that M3-S3, S4, and S5 are often mixed suggests that the "primary outcome can be deemed to reside in their methodological innovations" in IE, which sheds light on the priority and focus of this sub-discipline" [1].

4.4.4. M3-S4 (Stating the Value of the Present Research)

M3-S4 is the second most frequent step, occurring in 31 (77.5%) of the RAs. It is noted that in 27 out of the 31 RAs, researchers use exact phrases *'main contributions'* or *'our contributions'* to state the value of their work. In other cases, nouns such as *"focus"* (DRA1), *'novelty and contributions'* (DRA8), *'distinguished features'* (HRA7, ZRA2), *"our differences"* (ZRA5), and *"advantages"* (HRA5) are used respectively to indicate the creativity and unique aspects of their research. Additionally, to reinforce and clarify the advantages and merits of the current work in certain specific aspects, researchers usually use comparative expressions such as *"in contrast to"*, *"different from"*, *"comparing with"*, *"compared with"*, *etc.*, as well as finite structures as shown in examples (33-35, in appendix 1).

This study seems to indicate that researchers in IE are inclined to categorize M3-S5 (*Rationalizing research focus and design*), M3-S3 (*Summarizing methods*), as well as M3-S6 (*Announcing results and discussion*) all as the contributions of their research. This shows that the essence of study in IE is a "knowledge of the parts, mechanisms, and functions of the thing being described" [50]. The verb forms in simple past and simple present, as well as descriptive announcements, are used to demonstrate what, why, and how something is done in this lesson. Engineers in IE may be curious about the following: "Did you build it? Does it work? How long? How fast? Because they want to use it. They want to see some proof of concept." This may explain why IE adheres to this practice and inclination" [2]. If the methods description and procedural justifications are both taken into account, the percentage of M3-S4 will be much higher.

4.4.5. M3-S5 (Rationalizing Research Focus and Design)

M3-S5 comes fourth in frequency, with an occurrence of 19 out of 40 (about 48%). Rationalizing research focus and design, or in other words, justifying procedures, occurs to a large extent due to the nature of this discipline in which researchers attempt to propose a new method or an algorithm to solve an existing realistic problem. In order to justify and convince the feasibility of their novel idea, researchers are obliged to collaborate on the formulation of their proposed algorithm, methods/approaches, protocols, *etc.* Like M3-S6 (Announcing and discussing results), in most cases (15 RAs (about 79%)), M3-S5 is seen incorporating into M3-S4 (Stating the value of the present research), with only 4 RAs (DRA2, DRA7, HRA7, SRA7) (about 21%) of the total 19 RAIs justifying their procedures independently, two of which are given below (examples 36 and 37). Prepositional phrases (e.g. '*at…stage*'), infinitive structures (e.g. '*to*'), and logic connectors to show cause and effect relations (e.g. '*since*'), and passive forms of method-related verbs (e.g., '*developed*', '*applied*', '*used*', '*designed*', *etc.*) are frequently used in this step to clarify the stage-by-stage processes and procedures. The simple present tense seems to be dominant in this step.

4.4.6. M3-S6 (Announcing and Discussing Results)

M3-S6 is actually the third most frequent step, found in 29 (about 70%) of the RAIs. What is worth noting is that among the 29 RAIs that announce the results and discussions, twenty (about 69%) intertwine this with the contributions, as shown

in examples 33 and 34. Examples 38-41 display parts of M3-S6 in this study that contain isolated results and discussions. In the sentence-subject position, the first-person pronoun "*we*" and the descriptive nouns (e.g., "*this approach*", "*this paper*", *etc.*) alternate with each other. The predicate verbs are characterized by words emphasizing the status quo or result (e.g., "*prove*", "*show*", "*exhibit*", "*lead to*", "*improve*", *etc.*), and the present simple tense is usually the norm in this step.

4.4.7. M3-S7 (Limitations)

In only two RAs (SRA9 & ZRA8) (5%), researchers point out the limitations in the projected methodologies or algorithms by using concessive conjuncts in the form of contrastive adverbs such as '*however*', or using concessive conjuncts in the form of adversative prepositional phrases '*despite*', together with descriptive adjectives or nouns such as '*only*' and '*limits*' to show the limitations of the present work (See examples 42 &43, in appendix 1).

4.4.8. M3-S8 (Outlining RA Structure)

M3-S8 (Outlining RA structure) is the fourth most frequent step in IE RAIs, occurring 27 times (about 68%), which is much higher than in previous research [34]. The rhetorical and linguistic features of this step are simple and fixed (See examples 44 and 45). The simple present tense is dominant, and the active voice alternates with the passive voice, with the former appearing to take a larger percentage.

4.4.9. M3-S9 (Explaining a Mathematical Model)

Fourteen (about 35%) of IE RAIs contain M3-S9 (presenting mathematical notations), which either begins with "The notations used" or is located under the term "Notations" or "Notation" at the very end of the introduction section (See the Appendix 2).

5. Conclusion

This study aims to determine the rhetorical and organizational structure of IE RAIs by selecting 40 RAs from the top-class English journals in this academic community and tagging the moves and steps based on the framework adapted from Swales [1] and Swales [2] CARS model and previous research. The results show that IE RAIs follow the CARS model in the three obligatory moves, but the specific steps in move three indicate certain differences from Swales' seven steps in the following three aspects. First, in IE RAIs, researchers are inclined to present the mathematical notations, which often come as the final part of the introduction, with or without a layout. Second, expressions demonstrating the research hypotheses or questions do not function as what they are supposed to be. In IE, expressions such as "assumption" and "hypothesis" serve as the scientifically rational conditions under which the experiments or methods, *etc.*, are implemented, rather than those to be tested. Therefore, despite occurring 4 times, they are not identified as an optional step. Third, in IE RAIs, researchers sometimes point out the limitations of their methods, approaches, algorithms, control protocols, *etc.*, occurring only in two RAs.

The results also demonstrate that IE researchers tend to mix the method summary (M3-S3), state the value of the present research (M3-S4), and rationalize research focus and design (M3-S5), which indicates that the contributions, emphasis, and focuses of this engineering sub-discipline lie in their "methodological innovations" [1].

The observation indicates that the obligatory and quasi-obligatory steps in IE RAIs are M1-S1, M1-S2, M1-S3, M2-S1, M2-S2, M3-S1, M3-S5, M3-S7, and M3-S9. In addition, M3-S6 appears in almost half of the RAs. As a result, the findings of this study might contribute to helping IE EAP instructors adapt the generic CARS model and prepare learning materials for IE students.

In addition, this study sheds light on EAP pedagogy in two aspects. First, EAP instructors can impart the knowledge generated from the study to their advanced degree engineering students to improve their skills in reading and writing RAs in their disciplines. Second, for IE EAP students and scholars, awareness of and sensitivity to the rhetorical structure and linguistic features of each move and step of IE RAIs can facilitate and enhance their success in international academic communication, whether in academic reading or writing.

One prominent advantage of this study is that all the selected materials are closely related to each student's research directions, which motivates and benefits them to the fullest extent possible. As a result, all students showed great interest in the move analysis. In addition, whenever they are stuck in the process of move and step tagging, the researcher of this study and the students can turn to the degree advisors for help, which, to the largest extent, guarantees the accuracy of the tagging and analysis.

Since this study mainly aims to seek the unanimous rhetorical similarities of this engineering sub-discipline, the slight differences among the four research directions are not compared. Further studies can extend on this aspect.

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Appendix 1

1. Antibacterial surfaces are essential to reduce infections and illness in a wide variety of applications such as medical devices … Surfaces that are antiviral are also of much interest for these applications. The most prevalent antibacterial strategy employs antimicrobials such as organic compounds like triclosan and zinc pyrithione or metallic ions … (RA 11, p. 1)
2. In recent years, technology has been rer widely used to support classroom teaching, and the Internet has played a significant role in education classrooms. (S2) The advancement of technology and the Internet has enabled learners to engage in learning anytime anywhere with various high-tech learning tools available for their choosing. [JAT, 17(4), 2020, 1363–1376]
3. Wood pellet production is a well-established and rapidly expanding industry worldwide, including in the United States and Canada where the annual production is nearing 4 million metric tons. In the province of British Columbia, the industry has grown from 50,000 tons in 1996 to an expected 1,500,000 tons in 2010
4. Legionellae are widespread in both natural and man-made aquatic habitats. Among the 51 species described so far, Legionella pneumophila is the most causative agent of legionellosis, but it is often difficult to isolate from environmental samples because of the presence of heterotrophic-associated bacteria that frequently overgrow on culture plates.
5. It is well known that having strong and supportive social relations is beneficial for several different outcomes (House et al., 1988; Call and Mortimer, 2001; Malecki and Demaray, 2003; Cohen, 2004). We also know that social background influences our living conditions and opportunities in several ways (Breen and Jonsson, 2005; Conger and Donnellan, 2007).
6. Meat tenderness is an important issue in beef cattle because it has a major impact on consumer satisfaction. However, beef meat quality is not routinely measured, so a classical selection based on records is not feasible.
7. The emission from low-mass X-ray binaries in quiescence (qLMXBs) is routinely studied to provide useful constraints on the physical models of the interior of neutron stars (NSs). The low luminosity (1032-1033 erg s-1, 4-5 orders of magnitude lower than the outburst luminosities) of these objects was first observed in the post-outburst stages of the transient LMXBs Cen X-4 and Aql X-1 (van Paradijs et al. 1987), and initially interpreted as a thermal blackbody emission powered by some low-level mass accretion onto the NS surface (Verbunt et al. 1994)
8. Several characteristics of computers that execute such applications make them unsuitable for storing sensitive information. First, the devices may be poor and …. Second, can be easily stolen or …. Third, when data size become large, storage management is expensive and prone to errors. (INTR 45).
9. However, most of the existing database models are designed under the assumptions that the data/information stored is precise and queries are crisp. In fact many of these assumptions are not valid for many of the next generation information systems since they may involve complex information with uncertainty. In general, data/information in databases may be uncertain for the following reasons: A decision in …. Integrating data from … Information in some traditional … In natural languages, … (INTR 58)
10. DNS-dispatcher-based systems can easily scale from locally to geographically distributed Web-server systems … [23]. However, dispatching requests through the DNS has three problems that prevent … These issues have been addressed through ….[8], or multiple tiers of … [15]. This last approach has three main drawbacks. To avoid a system bottleneck

at the A-DNS, the traffic … requires … Moreover, if any client request… [21]. Finally, the TTL period …. is considered too low. (INTR 40)

11. Carbon nanoparticles are a promising alternative to semiconductor nanocrystals as next generation green nanomaterials … (RA 12, p. 1)
12. Sargent et al. [15] demonstrated that BiOBr-templated catalyst preferentially exposed high CO2RR activity Bi (110) facets … (RA 29, p. 2)
13. [M2S1A] Such designs, although well demonstrated in probabilistic computing applications, still have essential limitations: (i) the data retention time (i.e., dwell time) is determined by the energy barrier… (ii) Additionally, it is difficult to fabricate a chip with a tight statistical distribution around a small energy barrier for all devices… (iii) A feedback loop is needed for each MTJ to … (RA 13, p. 2)
14. [M2S1B] In this paper, as a complementary approach we report on a detailed study of the influence of oxygen and water on the electrical conductivity of GaN NFs … (RA 16, p. 2)
15. This approach offers several advantages: it can be applied to industry-standard perpendicular MTJs and allows the p-bits to be updated with a high speed and on-demand, comparable or faster than p-bits based on superparamagnetic in-plane MTJs. Furthermore, … (RA 13, p. 2)
16. In this work, we map both LSPR modes (dipolar and higher order polarities) and VP modes in nanorod clusters (hexamers and tetramers) fabricated by electron-beam lithography (EBL)… (RA 17, p. 2)
17. What fundamental physico-chemical processes occur when the printed NP ink traces are subjected to simple heating-based sintering? This has been an important question that needs to be answered … (RA 14, p. 2)
18. Zeolitic imidazolate framework-8 (ZIF-8), a typical type of metal–organic frameworks (MOFs) with zeolite topology, is considered as a biocompatible nanobot matrix, … (RA 25, p. 2)
19. In the same stream, the present paper proposes an alternative methodology to measure both the thermal diffusivity and conductivity of GNP strips, … (RA 15, p. 2)
20. The results showed that GA-nCeO2 hydrogel scaffold exhibited a typical three-dimensional porous structure with a mean pore ratio of 70.61 ± 1.94%. (RA 48, p. 6561)
21. Our study brings knowledge for the potential application of nanostructured biomaterials to work as an integrative platform under the detrimental metabolic status present in diabetic conditions. (RA 50, p. 1)
22. The paper is organized as follows. The methodology is detailed in section 2, … (RA 15, pp. 2–3)
23. Physical damage mainly contributes from its large surface area and sharp edges. The large graphene nanosheet would entrap the bacteria to prevent the nutrient supply to starve the bacteria, while the sharp edges would penetrate the bacterial membranes to extract phospholipid molecules destructively, and then damage RNA to exert antimicrobial effect. (RA 45, p. 4508).
24. Cell viability was calculated according to the following equation. (RA 31, p. 3)
25. Ferric chloride (FeCl3) and TA were obtained from Sigma Chemical Co., Ltd. (Saint Louis, MO, USA) … N-hydroxysuccinimide (NHS) and triptolide were from Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China). (RA 35, p. 3).
26. The custom-built Kelvin probe setup is equipped with a commercial controller (Kelvin Control 07, Besocke DeltaPhi) and a piezoelectrically driven gold grid with a diameter of 3 mm and a work function (WF) of 4.9 eV as a probe. (RA 16, p. 3)
27. [M3S3] After centrifugation three times for washing, then the cells were dissolved into the binding buffer. Annexin V-FITC and PI were added (BioVision, Milpitas, CA, United States), and the cells were incubated for 10 min at room temperature in the dark. (RA 31, p. 3)
28. The human subject protocol was approved by the Biomedical Research Ethics Committee of Shandong Provincial Hospital. … (RA 43, p. 5945)
29. Dimethylsulfoxide (DMSO) and tetrahydrofuran (THF) were purchased from China National Medicines Co. Ltd. (RA 47, p. 6608)
30. SPSS 19.0 and GraphPad 9.0 were used for statistical analyses. All data were presented as mean ± standard deviation (SD). One-way analysis of variance (ANOVA) was used for comparisons of multiple groups. A t-test was followed for comparison between two groups, and the statistical significance was defined as * $p < 0.05$. (RA 1, p. 19)
31. CPD measurements were performed in the same measurement chamber on commercially available not intentionally doped free standing bulk m-plane GaN plates (MSE Supplies LLC) and … (RA 16, p. 3)
32. To further determine the components of the hybrid interface after reacting, cryo-transmission electron microscopy (cryo-TEM) was used to analyze its crystal structure and electronic information. (RA 26, p. 5)
33. The experiments unravel two key issues. First and foremost, it established that there is polymeric surface coverage … Second, it provided an estimation of the pore fraction in the sintered traces… (RA 17, p. 5)
34. Compared with the control group, a significant reduction (60.1 and 60.2%) in cellular uptake was observed at 4°C and with colchicin, a microtubule-disrupting drug. (RA 31, p. 8)
35. With such a geometry, we see that the conductivity is now dependent on the direction of electric field … (RA 14, p. 7).
36. These results indicate that GBT has a significant ability in promoting cell proliferation and migration, which favors the wound healing process. (RA 45, p. 4514)
37. These results should be attributed to the facilitated Zn deposition on Sn@Zn foil, as supported by the EIS spectra of Zn–MnO2 batteries based on different anodes (Fig. 6f). (RA 24, p. 8)

38. These results are in accordance with the literature, which reports an oxygen-induced Fermi level pinning for polar GaN surfaces [34] and GaN NWs [20], [35] (RA 16, p. 7)
39. However, we encountered several experimental challenges with the control groups during the course of the study. First, it was difficult to quantify the concentration (or dose) of ginseng and … This made it problematic to directly conduct in vitro and in vivo experiments … we were not able to anticipate obtaining meaningful results with them… (RA 31, p. 17)
40. Therefore, compared with the nanofiber composite membrane, the NCRO enables more excellent long-term sensing stability and durability. (RA 21, p. 13)
41. This work revealed a novel role of NSC-exo on wound healing, which might contribute to the development of novel therapies for skin injury in the future. (RA 49, p. 5993)
42. Therefore, it is urgent to find a solution to overcome this shortcoming, so as to facilitate the better application of white light. (RA 47, p. 6615)
43. In summary, we have constructed a novel microbiotic nanomedicine Cu2O@ΔSt by anchoring Cu2O NPs on the surface of engineered Salmonella typhimurium strain for achieving … (RA 28, p. 19)
44. In summary, vertical 3D NiO nanoflakes and NiMoNH nanopillars have been successfully synthesized to use as electrocatalysts for the anodic GOR and cathodic HER, respectively … The as-assembled electrolyzer exhibits good HER performance and long-term stability. (RA 22, p. 11)
45. More importantly, in vivo infected-wound healing treated by GBT exhibited faster collagen deposition (with almost no scar formation) and accelerated regeneration of skin tissue at the end of 8 days. (RA 45, p. 4517)
46. Nevertheless, the simplicity and versatility of the nanobot-assisted cell recognition and isolation offer a novel tool for diverse biomedical applications, highlighting foreseeable clinical and commercial opportunity. (RA 25, p. 12)
47. This work opens a new avenue for the practical applications in the future hydrogen economy. (RA 22, p. 11)
48. Although the low level of H2O2 used in this study shows minimal impact on the cell viability, future research directions in nanobot formulation could exploit alternative and … (RA 25, p. 12)
49. We anticipate that future studies will delve into the examination of GENs in combination with conventional drugs, explore other applications of GENs, and investigate possible modifications to enhance their targeting ability. (RA 31, p. 17)

Appendix 2.

Moves And Steps	**Tagging Category**	**RAS**	**Occurrence**	**Percentage**	**Purpose**
Move 1	establishing territory	IE RAIs	40	100%	Obligatory
M1-S1	asserting one's dominance),	IE RAIs	39	97.5%,	Quasi-Obligatory
M1-S2	generalizing about a subject	IE RAIs	38	95%	Quasi-Obligatory
M1-S3	perusing elements from prior studies	IE RAIs	40	100%,	Obligatory
Move 2	Establishing the niche	IE RAIs	38 RAs	95%	Quasi-Obligatory
M2-S1	Indicating a gap	IE RAIs	38 RAs	95%	Quasi-Obligatory
M2-S2	adding to what is known	IE RAIs	10 RAs	25%	Optional
M2-S3	Presenting positive justification	IE RAIs	21 RAs	53%	Quasi-Obligatory
Move 3	presenting the present work	IE RAIs	40 RAs	100%	Obligatory
M3-S1	Reporting about ongoing studies in a descriptively or purposeful manner	IE RAIs	40 RAs	100%	Obligatory
M3-S2	Definitional clarification	IE RAIs	3 RAs	7.5%.	Optional
M3-S3	Summarizing methods	IE RAIs	15 RAs	37.5%	Optional
M3-S4	Stating the value of the present research	IE RAIs	31 RAs	77.5%	Quasi-Obligatory
M3-S5	Rationalizing research focus and design	IE RAIs	19 RAs	48%	Optional
M3-S6	Announcing result and discussion	IE RAIs	29 RAs	70%	Quasi-Obligatory
M3-S7	Limitations	SRA ZRA	2 SRA9 & ZRA8	5%	Optional
M3-S8	Outlining RA structure	IE RAIs	27 RAs	68%	Quasi-Obligatory
M3-S9	Explaining a mathematical model	IE RAIs	14 RAs	35%	Optional