Components of the Discussion Section in Biomedical Engineering Research Articles and their Linguistic Characterization

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Abstract

This study aims to develop the academic writing skills of biomedical engineers by analyzing a dataset of 37 discussion sections in biomedical engineering research articles written in English. Specific objectives of this study are twofold: 1) to identify the components that make up this section classified as 'moves' and 2) to describe how each component of move is expressed. First, the analysis reveals that this section consists of three principal moves, and each move possibly entails a number of sub-units called 'steps'. The analysis also demonstrates that these units of texts are organized in a particular pattern forming a typical sequence. Second, the examination to scrutinize how these textual units are written shows that a number of linguistic features are conventionally used to serve a particular purpose. This study bears pedagogical implications preparing scholars who are not competent in English to be able to disseminate their scientific achievements regionally and internationally.

Introduction

It is known that the ability to write like a professional is a central requirement for a successful career.[1] Given that professional scientific and engineering fields are dominated by English,[2] the policy 'publish or perish' in an international journal has been adopted by several universities and academic institutions. At this juncture, being competent in scientific writing and discovery dissemination embodies a knowledge of the genre and its associated textual features including lexico-grammatical features, organization, communicative functions, disciplinary conventions (how to report numbers and units, format tables), and content.[3-6]

Typical academic genres in which scholars and practitioners are involved include research articles (RAs), research proposals, and conference abstracts, Apparently, RA genre has become one of the primary means by which new scientific discoveries and claims are disseminated in various disciplines.[7]

A number of studies focus on different sections of RAs. Since Swales[8-9] developed his ground-breaking framework for analyzing RA introductions, the introduction section has been a particular focus of attention.[10-11] The framework has served as a foundation for research into the other conventional sections of empirical RAs, namely, Methods,[12] Results,[13] and Discussion.[14] Moreover, the framework has stimulated a range of discipline-specific and cross disciplinary studies of different sections of RAs.[15-16] A much smaller number of research studies were conducted on full-length articles.[17] All these studies have demonstrated the power of genre or move analysis as an effective tool to elucidate how academic written discourse is constructed and consequently facilitates the learning and/or instruction of academic writing.

A review of genre-based studies reveals that, among the four conventional sections of RAs, whereas the Introduction section has received relatively substantial interest, few studies focus on the discussion section[17]

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Despite some commonalities shared across disciplines, these studies congruently reveal that disciplinary variation is discernible.

Biomedical engineering, as a discipline, plays a pivotal role in our life, focusing on the use of the principles and techniques of engineering to solve problems in biology and medicine. However, very little appears to be known about RA writing in biomedical engineering. Therefore, the present study aimed to develop the academic writing skills of biomedical engineers, by examining biomedical engineering RAs with reference to Swales' schematic framework. In fact, this study, as a part of a larger project that focuses on the four conventional sections of full length RAs, focuses on the discussion section of biomedical engineering RAs.

Specifically, the objectives of this study are twofold: 1) to identify the components of this section or so-called move or text structure, and 2) to linguistically characterize individual components or moves inherent in this section. It is anticipated that this study will be able to cater to the demand of academic and professional uses of English, preparing them for engineering communication in the genre of RAs. The text structure outline, combined with the linguistic description, implicates that developing reading and writing skills of this particular genre can be accomplished with explicit instruction.

Experimental

Analytical framework of move analysis

Genre or move analysis created by Swales[18-19] is recognized as a textual analysis approach that identifies textual organization originally in the academic English discourse of Introductions, and subsequently extended to other sections of RAs. In brief, this textual analysis approach considers that each genre has a pattern, consisting of sub-units called 'moves'. Each move, in turn, possibly consists of a number of 'steps' or sub-units of a move. The textual segmentation was manually conducted based on the communicative function of a text segment and the linguistic features associated with the function.

Journal article dataset selection and compilation

Journal and journal RA selection were conducted to assure that the dataset analyzed represents the top five quality journals in the field of biomedical engineering. Based on the impact factors of journals in the discipline of biomedical engineering in 2005 (the most recent data available at the onset time of dataset compilation), five journals were selected. From each journal, twelve RAs were randomly included in this dataset. In short, the dataset consists of 60 biomedical engineering RAs published in 2006.

Despite the growing frequency of a combined results and discussion section in many academic disciplines, for pedagogical purposes, this study was designed to analyze the stand-alone discussion section, because it was important for students who are unfamiliar with the genre to be able to understand and to distinguish the distinct functions of the discussion section as revealed by their conventional moves.

Given that the focus of this paper is on the discussion section, only RAs from the original dataset that have a distinct and stand-alone section of discussion were analyzed. From the original 60 RA dataset, the final dataset to be analyzed by genre or move analysis in this study consists of 37 discussion sections.

Dataset analysis

The 37 discussion dataset was analyzed by Swales' move analysis. That is, discussion texts were hand-tagged or segmented into textual units called 'moves' and their sub-units called 'steps', based on their communicative functions and associated linguistic features. Finally, based on the moves and steps identified, text organization of the discussion section in biomedical engineering RAs is outlined, together with their frequency of occurrence. The organization presented, however, represents only one common channel of disseminating biomedical engineering knowledge in the RA genre.

Results and Discussion

The analysis of the discussion section reveals three major moves. They are *Move 1: Preview the present*

study, Move 2: Consolidate results, and *Move 3: State limitations and possible future research.* These three moves are presented in the order likely to be found in the dataset. In order to characterize the linguistic features associated with these moves, in the second objective of this study, representative examples displaying exact verbatim of these moves in the dataset were illustrated, with two modifications: 1) replacing citations with (R), and 2) replacing people's names with XXX. Finally, linguistic features that are associated with a particular move are highlighted.

Move 1: Preview the present study

Move 1: Preview the present study usually reminds readers of the purpose and the major methodological features of the study, as shown.

*(1) **It is well known that** dynamic properties of closed-loop force controlled robotic devices **get** worse if the coupling between the robotic device and the object, to which the force **is** applied, gets stiffer **(R).***

*(2) Accuracy of the models generated with the scanner method in our study **was determined** by **comparing** data derived from the virtual images with reference values obtained by manual measurements on the dummy.*

Instance (1) demonstrates that Move 1 can accomplish its function, for instance, by providing the background of the research topic. As shown, the construction of *it is + past participle + that* clause and the use of reference (R) are used to express the established background information. In addition, the use of present tense verbs (*get, is*) indicates the contemporary nature of the statement.

However, (2) represents a variation of Move 1 that opts to provide a brief description of the methods (*determined* and *comparing*) employed by the present study. In this regard, it is noted that the verb was in past tense (*determined*) to highlight the completion of the activity mentioned.

These two instances of Move 1 successfully assure readers that the present study was contextualized, based on background information, and carefully planned and executed. In short, this move provides readers with a snapshot or an overview of the study.

Move 2: Consolidate results

Not all discussion sections in biomedical engineering begin with Move 1. In the absence of Move 1, the discussion sections are likely to begin with *Move 2: Consolidate results*. In this move, major results are initially and frequently highlighted and subsequently strengthened by one step or a combination of some of the seven steps to serve a range of functions, as detailed below.

Move 2, Step 1: Report results

In order to strengthen the results generated by the study, it is crucial that a finding be primarily introduced to be subsequently discussed.

*(3) None of the investigated materials **showed** any significant acute or chronic inflammation at or after 7 days post-implantation…*

*(4) Table II and Figs. 8 and 9 **show** that contrast normalization improves the discrimination ability of individual features.*

As shown in (3) and (4), the verb *show* is prominent, varying in tense, either past or present, stating a finding of the present study. It is noted that in this discipline of biomedical engineering, the tense choice of this particular verb seems to be determined by its subject. That is, when the subject is *Table* or *Figure*, the verb *show* is in the present tense. However, the verb *show* in past tense is used when the finding is reported. The presence of this move/step, the centerpiece of the discussion section, provides a basis for the other steps of this move to consolidate findings, frame arguments, stake claims, etc.

Move 2, Step 2: Interpret results

After a result is presented, one of the most common attempts or strategies to highlight the result is by means of interpretation. Thus, the section usually proceeds with an interpretation of results.

*(5) This **suggests** that the added sensory information about body sway enhanced the natural, direction specific, automatic postural control strategies rather than superimposing a generalized stiffening.*

*(6) Incubation of Promogran in a buffer containing purified neutrophil elastase **indicated** that the protein component of the dressing material is susceptible to degradation.*

In (5) and (6), the verbs *suggest* and *indicate* (be they in present or past tense) congruently express the researchers' interpretation of the findings.

Move 2, Step 3: Explain results

It is also common that the presentation of a finding needs to be accompanied by possible explanations. Scientific results do not speak for themselves.

*(7) These differences are mainly **attributable to** the limitations of the CDPIV system to measure velocity larger than 20 cm/s.*

*(8) This **may** be **because of** interdependencies between the occurrence of MAs in an image.*

The phrases highlighted (*attributable to, because of*) contribute to the function of offering explanations for the findings. The explanation appears to involve a certain level of speculation, and thus the modal *may* is concurrently used in (8).

Move 2, Step 4: Compare results

A study can be consolidated and contextualized by comparing the results of the present study with those of previous studies.

*(9) The low localization errors and the relatively high magnitude changes are **in good agreement with** the results of XXX **(R).***

*(10) Fiber strain predictions from the normal FE model were **in good agreement with** the predictions of the cylindrical numerical model developed by XXX **(R).***

Both (9) and (10) display the use of the phrase *in good agreement with* to highlight the compatibility and support of the results of the present study with those generated from previous studies (indicated by *R* or citations). By comparing findings, the present study is connected to a larger body of evidence.

Move 2, Step 5: Conclude results

Multiple findings produced by a study in biomedical engineering can lead to a conclusion or a brief summary of the work, as shown.

*(11) **Overall, this study demonstrated** a multimodal method for assessing biocompatibility in preclinical testing of cardiovascular devices.*

*(12) **On the whole, our study showed** no essential correlation between the precision of the models*

created with the scanner method and the orientation of the scanner laser beam.

Both (11) and (12) use connectors like *overall* and *on the whole* to conclude the findings. In addition, the use of *this/our study* indicates the authority of the researchers in stating such a claim or conclusion. Finally, the use of reporting verbs in past tense (*demonstrated, showed*) to conclude the findings suggests that the authors do not seem to claim a generalization of the conclusion(s) presented.

Move 2, Step 6: Exemplify results

To substantiate a claim, statement, or argument, examples can be quite helpful in convincing readers.

*(13) **For example,** rats would turn their heads left or right, duck, or paw at the food aperture upon tone onset during many of the experiments.*

*(14) **For example,** in images containing MAs at various stages of development and hence having a range of sizes, it is not important to detect the small faint MAs as long as the largest MA can be detected.*

In these two instances, the phrase *for example* clearly serves the purpose.

Move 2, Step 7: Claim values of the results

Even though it is apparent that our life quality enhancement is in the hands of biomedical engineers, they still feel the need to explicitly justify the value of their findings.

*(15) Automation as a prescreening phrase of image grading will make screening programs **more cost effective** by reducing the manual grading workload.*

*(16) The present study provides significant evidence demonstrating that a number of ionic derivatives of a 60 mol% S-SEBS polymer offer **some significant advantages** as wound dressing materials.*

As shown, biomedical engineers stake their claims about the contribution, application, and implication of the findings by assuring readers that their discovery is *cost effective* and *advantageous*.

In summary, of all of the seven steps of Move 2, Step 1 seems to be the center of the discussion. Based on this move/step, a number of reactions are proposed:

interpretations made, explanations offered, comparisons conducted, conclusions framed, examples provided, and values of the findings claimed.

Move 3: State limitations and possible future research avenues

In this move, biomedical engineers opt to express opinions regarding the limitations of the study (17). This move allows the researcher to caution readers that the study was not perfect, and thus finding interpretation and implication should be conducted with care. In some discussion sections, the authors offer possible avenues or directions for future research (18).

*(17) The scope of the proposed model is **limited** to objectively assess technical factors of surgical ability.*

(18) Other approaches are currently emerging that seem to hold promise for further progress, such as halography, which features millisecond exposure times and an excellent depth of field.

(17) and (18) illustrate how biomedical engineers move the field forward. By explicitly stating limitations of the present study and suggesting directions for future research avenues, scholars in the field are aware of some potential weaknesses inherent in the present study and can mobilize concerted efforts to enhance the quality of future research.

Pattern of move structure or text organization

The moves and steps presented above seem to be in congruence with what previous studies on this section of a range of disciplines[14,17] have revealed. That is, the section consists of three major moves; some moves with a number of steps. Moreover, as far as patterning is concerned, how the three moves and their constituent steps interact with each other are multiple and varied. However, in this article, to facilitate scholars in the field who are involved in the task of writing RAs, the pattern presented here reflects one of the many possible but common ways to organize discussion texts.

Move 1 (*Preview the present study*), if found, is likely to begin the section, followed by Move 2 (*Con-

solidate results*). Similarly, Move 3 (*State limitations and possible future research avenues*), if available, is likely to end the section. If all are found, these three moves tend to occur in a 1-2-3 sequence or pattern. In addition, cyclical patterning of Moves 1 and 2 is frequently found in this dataset.

As previous studies indicated[14,17] although the moves and steps are commonly found across disciplines, each discipline seems to have its own preference.

It is observed that some moves occurred more frequently than the others. That is, some moves are considered relatively optional, whereas others are relatively conventional. In order to indicate the status of each move (be it optional or conventional), the frequency of occurrence was used as reference, with an arbitrary cut-off of 60%. It was found that Moves 1 and 2 are interestingly equally frequent, with 94.59% of occurrence, being found in 35 out of a total of 37 discussion sections. Move 3 is slightly less frequent, found in only 29 sections or 78.38%. At this juncture, it can be concluded that these three moves are quite conventional, with more than 60% of frequency occurrence.

An examination of the frequency of occurrence is also intriguing. At the step level, the frequencies of the seven steps of Move 2 vary substantially. *Step 1: Report results* was found in all except two discussion sections (94.59% or in 35 out of 37 sections). The other six steps, in the order of more frequent to less frequent, are *Step 2: Interpret results* (89.19% or in 33 sections), *Step 3: Explain results* (75.68% or in 28 sections), *Step 4: Compare results* (67.57% or 25 sections), *Step 5: Conclude results* (43.24% or in 16 sections), *Step 7: Claim values of the results* (40.54% or in15 sections), and *Step 6: Exemplify results* (16.22% or in 6 sections).

The data above demonstrated the specific nature of this section of biomedical engineering. That is, biomedical engineers prefer the strategies of reporting results the most (Step 1, about 95%), followed by interpreting sections (Step 2) and explaining results (Step 3), with more than 70% of frequency occurrence. The least preferred step of Move 2 is exemplifying results.

Conclusion

It is known that developing academic writing is a great challenge. To address this challenge, this study has presented a detailed analysis of the move structure found in 37 empirical discussion sections. Although the discussion section is not claimed to be a default option for organizing RAs, this section is considered to be one of the standard sections for a number of disciplines.[8,9,17] Moreover, this section is distinct, making connections between the new knowledge or understanding reported in the result section and previous studies in the field. As shown, in order to succeed in writing this section, authors need to have not only novel, original, exciting results but also the skills and expertise to develop, evaluate, communicate, and argue persuasively to support the claim or evidence offered in order to maintain credibility. It should be noted that the pattern outlined and presented in this article is not meant to be a recipe. Rather, it should be treated as one of the many possible ways to be successful at conveying a message by writing the section following the academic norms. It is anticipated that the components identified in this section and the linguistic characterization of individual components will also allow particularly novice readers to follow the flow of the biomedical engineers' thoughts. For scientists in peripheral countries, this study will help them to become fully integrated members of the worldwide network of science.

Acknowledgement

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